PHYSIOLOGY OF GROWTH AND REPRODUCTION OF CERTAIN INSECT PESTS OF AGRICULTURAL CROPS IN RELATION WITH SOME EXOGENOUS FACTORS

M. Phil. Dissertation

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C E R T I F I C A T E

This is to certify that the research work presented in the dissertation entitled "Physiology of growth and reproduction of certain insect pests of agricultural crops in relation with some exogenous factors" by Mr.Khowaja Jamal is original and was carried out under my supervision. He is permitted to submit it for the partial fulfilment of the degree of Master of Philosophy in Zoology,at Aligarh Muslim University,Aligarh, India.

Mumtaz A Khan

(Prof. Mumtaz A.Khan)

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INTRODUCTION

In insects reproduction and growth are controlled and influenced by several exogenous as well as endogenous factors. The exogenous factors include temperature, light, humidity, food, chemicals, including hormones and insecticides. Although a number of investigators have contributed information on the effect of these factors on various physiological processes in a number of species. Almost all of them concentrated their studies on the effects of one or the other factor. Therefore, there is paucity of complete data regarding the effect of various factors on growth and reproduction which include longevity, fecundity, fertility, and mortality etc. of a single species.

India is a developing country, relying heavily on agriculture for its economy. Population wise it ranks second in position which creates the problems of shelter and food. In order to raise yield in agriculture a large number of fertilizers along with pesticides are used. According to Pimental and Goodman (1974) there are now over 1000 chemicals used against 2000 pest.

After 1960, the other less stable chemical compounds came into light. These were organophosphates and carbamates.

Previously the USA was thought to consume 50% of the total pesticides produced in the world. However, today the usage of pesticide percentage in USA using synthetic chemicals has increased a lot. Other countries which earlier did not use large quantities of pesticides are now using them in large quantities (W.H.C., 1970). In view of the imperative need to increase food production and agriculture production, pesticide application within the country will further increase. A lot of research work has been done to determine the minute amount of insecticides in numerous crops following the use of various formulation of different insecticides. Residual effect of these chemicals have also been studied. To over-come the problem of resistance several methods have been put into practice, such as the alternate use of insecticides, use of two or more insecticides in combination, use of alternate methods and integrated pest control.

Besides insecticides, nutrition is also one of the important exogenous factors which plays important role in the physiology of growth and reproduction of certain insect pests. A number of researchers have been reported that mortality, longevity, development of oocytes, fecundity as well as fertility were affected by the quality and quantity of nutrition. In insects nutritional substances such as proteins, carbohydrates, fats, amino-acids, salts and vitamins are necessary for different physiological activities of life. House (1961) has discussed the nutritional requirement of different chemical substances by the insect. Both fecundity and fertility are dependent on adequate nutrition of larval stage as well as that of adults of a species.

With this view it was proposed to study the effect of the chemical (cythion, an organophosphate) and food on the growth and reproduction of Dysdercus cingulatus (Hem: Pyrrhocoridae) and Spodoptera litura (Lepidoptera:Noctiudae)

REVIEW

There are certain factors that effect the growth and reproduction of insects. These factors may be endogenous as well as exogenous. Several authors studied the effect of various exogenous factors such as food, chemicals, temperature, humidity etc. on various physiological processes of insects. The chemicals include insecticides, chemosterilents, hormones and pheromones etc.

Effect of chemicals on mortality, fecundity and fertility of insects:

Effect of different chemicals on orthopteron insects have been studied on a few species.

In 1982, A. Odjo et. al. studied the insecticidal activity of two Quassinoides on the larvae of *Locusta migratorioides* and found them anti-feed-ants against this species. Brucerne B and glaucarbinone showed especially significant insecticidal activity.

In 1982 S-J Lim and Lee found out that diflubenzuron retarded the ovarian development in *Oxya japonica* causing an increase in the percentage of terminal oocytes resorption. The fecundity of the females and egg hatchability were significantly reduced, in addition treated female showed characteristic tendency for the hind legs to break off the body. Ingestion of the compound decreased the life span of the adult females.

Further Elliott and Iyer (1982) observed that when nymphs of the migratory grass-hopper, <u>Melanoplus sanguinipes</u> were reared continuously on seedlings treated with diflubenzuron at concentrations of 10 ppm or above, the moulting of 2nd instar nymphs was completely inhibited.

<u>Hemiptera</u>:

Hodjat (1971) investigated that sublethal doses of dieldrin when applied topically to 5th instar nymphs of <u>Dysdercus fasciatus</u> at concentration 0.2-0.6 ug/individual, it resulted in increased egg production, at 0.8-6.0 decreased it and at 0.6-6.0 decreased fertility. Applied to adults, dieldrin at 2-4 μg reduced egg production and at 0.02-0.08 (♂♂) and 0.2-0.8 (♀♀) shortened the life span.

Effect of sublethal doses of Intration 50 on reproduction in <u>Pyrrhocoris apterus</u> was observed by Houck and Novak (1978). The sublethal concentrations equal to 25-50 ppm of effective substance (Thiometon) speeded up ovariole maturation during the activation of diapause individuals.

According to De Barr and Nord (1979), second instar larvae of <u>Leptoglossus corculus</u> were highly susceptible to most of 34 topically applied insecticides. Twenty six chemicals had LD-50 values of less than 5 µg/g of body weight. Nine insecticides had LD-90 values of less than 1 µg/g of body weight. There was good agreement between the relative toxicity of insecticides applied in the laboratory tests and the effectiveness of several insecticides previously tested in the field.

Hameed and Dinabandhoo (1980) made investigation on the toxicity and persistence of effectiveness of some organophosphorous insecticides against <u>Aphis gossypii</u>. Demethon-S-methyl, chlorfenvinphos and phosphamidon were highly toxic, dimethoate and phosleene were moderately toxic and monocrotophos , guinalphos and methamidophos were less toxic.

A comparative study of 9 insecticides for control of <u>Dysdercus koenigii</u> was done by Kumar, Singh and Chouhan in 1980. Order of toxicity was Baygon > Endrin > Dipterex > Sunithion > Ekatox > Rogor > Thiodon > Anatox > DDVP. Baygon gave 100% mortality with 12 hours of treatment at the lowest concentration of 0.06%.

Lepidoptera

There is a mass of information on the effect of chemicals on the lepidopterous insects which include most of the greatest enemies of agriculture.

Ovicidal effect of some insecticides was observed by Siddappaji, Prabhu and Desai (1979). Methamidophos, quinolphos and trichlorphon showed excellent ovicidal action (100% inhibition at 0.025% conc.).

Thomas (1979) found that susceptibility of female spruce bud worm moth, Choristoneura fumiferane to ULV aerial sprays of aminocarb and phosphamidon was dependent on the proportion of total complement of eggs female had laid.

Diflubenzuron applied to the surface of an artificial diet caused mortality to all larval instars of Trichoplusia ni, Spodoptera exiqua and Heliothis virescens. First 3 larval instars of these species were more susceptible than the later ones (Caudriet and Scay, 1980).

Markin, Batzer and Brewer (1979) concluded that small droplets of carbaryl and trichlorfon caused higher mortality of Dougles-fir tussock moth, Orgyia pseudotsugata (laboratory raised) and spruce bud worm, Choristoneura occidentalis (field population) than did larger droplets. Small droplets of acephate gave a higher mortality in the former species (in field) but were comparatively less effective against the later one.

In 1970 Livingston _et al_. determined that the selection of _Pseudoplusia includens_ larvae with higher dosages of beuomyl had little effect on susceptibility to methomyl through 11 selection cycles. In _Trichoplusia ni_ larval exposure to 3075 ppm (calculated LC 75) benomyl resulted in almost total sterility of males. While larval exposure to 5536 ppm caused a 40% reduction of viable eggs in adult crosses involving treated _P_. _includens_ males. Fecundity was significantly lower with crosses involving treated males than those with untreated males in _T_. _ni_. While no significant difference was apparent with those crosses in _P_. _includens_.

For the control of _Spodoptera frugiperda_ some new insecticides were tested and found effective. These included chlorophyrifas, larvin (dimethyl N,N: [Thiobis{ methyllimino } carboxyl oxy] bis [ethani midiothioate]) and monocrolophos (Young, 1980).

Pru and Hagley (1980) concluded that permethrin and azinphosmethyl were more toxic than phosmet to eggs of

Grapholitha molesta (OFM). Permethrin was more toxic to newly laid CM eggs than to OFM eggs. In field, permethrin reduced hatching of CM eggs for 17-21 days. All treatments reduced OFM egg hatching for at least 14 days.

Klein, Levski and Karen (1982) made observations on the comparative toxicity of several insecticides against eggs, larvae and adults of Egyptian cotton worm, Spodoptera littoralis in laboratory. Methyl chlorpyrifos, methidothion, ethyl parathion and methyl parathion were effective against eggs even at lower doses, Profeuofos and Phosfolan were less effective and azinphosmethyl was ineffective. The doses needed for 90% kill (LD-90) of the 2nd instar larvae were 8.5, 35, 280, 1,300 and 3,400 g.a.i./1000 m^2 for chlorpyrifos, methomyl, profeuofos, ethyl parathion and methyl parathion respectively. Monocrotophos was inactive against 2nd instar larvae even at relatively high doses.

The LD 90 of adult was reached with 16, 32, 1,700 and 6,100 g.a.i./1,000 m^2 of chlor-pyrifos, methomyl, ethyl parathion and profeuofos respectively. Only chlorpyrifos and methomyl gave successful control of all three stages of insects.

Wolfenbarger and Harding (1983) studied the effect of pyrethroid insecticides which is less toxic than cypermethrin on Heliothis virescens when applied topically.

Spraying of diflubenzuron and dimatif on the eggs of *Cydia pomonella* caused change in embryogenesis leading to inhibition of development in various stages (Mathion and Kuldova, 1983). Working on insecticides, Dabbour and Sayed (1984) come to the conclusion that Trichlorex was the only insecticides that caused significant increase in the duration of larval period. They also observed that Trichlorex, dichlorvus and nuvacorn resulted in a marked decrease in the fresh larval weight. However, pupation, pupal weight, and adult emergence ~~and~~ were not affected by any of these insecticides. An increase in the fecundity with carbaryl treatment, reduction in hatchability with lindane treatment were also reported.

Robertson and Smith (1985) studied the joint action of pyrethroids and insect growth regulators on *Choristoneura occidentalis* by contact or ingestion. The pyrethroids tested were femalerate and permethrim, the insect growth regulators tested were BAY SIR-B514 (N-(trifluero methoxy) phenyl carbonyl)-2-chlorabenzamid), diflubenzuron and methoprene. Mixtures consisted of 9:1 proportions of insect growth regulators: pyrethroid. When sixth instar larvae ingested permethrin combined with diflubenzuron significantly higher mortality resulted, then was expected under the model of uncorrelated independent joint action i.e. synergism was observed. Atlia and Frecker (1985), observed synergism and cross resistance spectrum in organic phosphorus resistant strains of *Oryzaephilus surinamensis*. Resistance to DDT, organophosphorus insecticides, viz. carbaryl, bioresmethrin and pyrethrins was found in wild strain of *O. surinaminesis*. The levels of resistance measured in these strains were low to DDT, dichlorvos, chloropyrifos methyl, bioresmethrin and pirimiphosmethyl and very high to fenitrothion.

Further, Attia (1985) reported that resistance to DDT, cyclodiene, BHC, and organophosphorus insecticides developed in Indian meal moth, *P. interpunctalla*, topical ware house moth *Ephestia cautella* and *Mediterranean* flour moth, *E. kulnniella*.

Later, wool and kamin-Belsky (1985) determined that malathion resistance of adult *E. cautella* is inversely related to adult age.

Coleoptera:

In 1970 Bliss *et al.*, made the evaluation of dieldrin, dimethoate and endosulphan as stump sprays for the control of the Pales weevil, *Hylobius pales* in central Pennsylvania in tests at a plantation in clearfield country. Dieldrin in oil and endosulfan in water at 7.8 ml insecticide/ lit oil or water killed Hylobius pales in fresh pine stumps. At 3.9 ml/ lit. only dieldrin in oil effectively controlled H. pales. Pissodes approximatus was effectively controlled by dieldrine, dimethoate and endosulfan at 7.8 and 3.9 ml/ lit in oil.

Erdman (1970) took different strains of Tribolium confusum and I. castaneum and sooly (mutant). They were fed on the diet containing DDT and then exposed to X-rays. Mortality of ♀♀ was greater than ♂♂ and reproduction ability decreased progressively with increasing X-ray exposure.

Four systemic insecticides disulfoton, dicrotophos, monocrotophos and aldicarb were evaluated for their effect on the longevity and fecundity of Anthonomus grandis. Mortality increased with time and increased doses. Also the rate of oviposition decreased during a 19-day period when weevils were continuously exposed to sublethal doses of the insecticides, greater reductions occurred at higher doses in all tests; aldicarb affected mortality and fecundity more than other insecticides (Bariola and Lindquist, 1970).

Taxophene + DDT, methyl parathion + DDT and taxophene + DDT + methyl parathion provided adequate control of Anthonomus *grandis* and *Heliothis zea*. Difference in effectiveness of the treatment were not significant. These insecticides caused delay in maturity, and reproductive physiology was slightly altered (Mistrii *et.al*., 1970).

Boles and Kansas (1971) stated that exposure of synergized pyrethrins to *Sitophilus oryzae* caused an increase in egg production.

Katiyar and Lemonde (1972) observed biological effects of some organophosphate and carbamate insecticides on the *Tribolium confusum*. All of the several insecticides tested prolonged the larval period of *T. confusum*. No distinction could be made in growth retarding effect between ♂♂ and ♀♀; pupal weight was not effected; egg production was stimulated by some insecticides and decreased by others. The same insecticides which increased and decreased the fecundity of adult ♀♀ also increased and decreased the viability of eggs.

Zettler and Luato (1974), reported that the production of progeny by *Tribolium castaneum* that survived LD-50 doses of malathion or dichlorvos showed lower fecundity and longevity than untreated animals.

El-Nahal and El-Halfawy (1974) showed that the sub-lethal doses of CS_2 decreased the oviposition period and the number of eggs laid per female to both the survivers as well as their progeny. Low sublethal doses stimulated the fecundity of the survivers of all 3 spp. Egg deposition was inhibited, hatchability decreased and the longevity became considerably less as compared to the control.

Hussain and Qayyam (1975) found out that when Diazinon, Malathion and Nogos were tested on larvae of *Trogoderma granarium* in relation to temperature and humidity, the mortality increased with increase in temperature and humidity.

Farnesol treatments were carried out by Azmy (1976), on larvae, pupae and adults of *Trogoderma granarium*. It was found that farnisol stimulated the hormone secretion by the carpus allatum caused retention of the larval characters, delayed eclosion of the adult ,induced yolk deposition in ♀♀ and activated the accessory glands to secrete their secretions. Disturbance of the hormone balance led to development of forms intermediate between larvae and adults.

Synthetic growth regulator, methoprene and hydroprene were tested against 6 spp. of stored product insects by Loschiavo (1976). Both of these compounds at 20 ppm prevented emergence of pupae of *Tribolium castaneum* and subsequently reduced it in *T. confusum*; inhibited oviposition, increased larval size which failed to pupate. They also prevented the emergence of adults in *Oryzaephilus mercator* and *O. surinamensis*. Complete inhibition of progeny took place in *Sitophilus granarium*.

In 1976, Page and Lyon tested 21 insecticides on adults and 7 of the 21 were tested on 3rd and 4th instars of *Chrysomela scripta*. Mexacarbate was significantly more toxic to the larvae than to the adults at both LD_{50} and LD_{90} Parker *et al*. (1977) concluded that sublethal doses of malathion had the greatest effect on fecundity at the higher doses used to *Menochilus sexmacutalus*. Reduction of longevity and viability of eggs with increased toxicant concentration was also observed. Tanton and Khan (1978) compared that Fenitsothion was 20 times more effective than amino carb.

Weiss (1978) reported that application of Dimilin on the adults of *Agelastia alni* decreased the number of egg clusters/female by about a half. Hatchability also decreased.

Gholson *et al*. (1979), studied effect of several insecticides on adult carabids, *Scarites substriatus*, *Harpalus pensylvanicus*, *Pterostichus calcites*, *Bembidion rapideum* and *B. quadrimaculatum*. They concluded that phorate and turbufos granules, carbofuran, methomyl, and carbaryl sprays produced high mortality, whereas carbofuran granules, carbaryl and leptophos baits caused low mortality in these beetles.

Effect of diflu-benzuron on black vine weevil <u>Otiorhynchus suleatus</u>, oviposition, eggs viability and fecundity were significantly reduced but adult longevity was not influenced (Zepp <u>et</u>. <u>al</u>., 1980).

Reproductive potential of 4 spp. of weevils, <u>Pachnaeus litus</u>, <u>P</u>. <u>opalus</u>, <u>Artipus floridanus</u> and <u>Diaprepes abbreviatus</u> was highly reduced when treated with Diflubenzuron (Lovestrand and Beavers, 1980).

Ottens and Todd (1980), observed that direct application of diflubenzuron to <u>Graphognathus peregrinus</u> eggs caused reduction in hatchability. Adult <u>G</u>. <u>peregrinus</u> and <u>G</u>. <u>leucoloma</u> fed on diflubenzuron treated foliage in the laboratory produced eggs with greatly reduced or no hatch.

Tamaki <u>et</u> <u>al</u>. (1984), studied the toxicity of diflubenzuron to larvae of the colarado potato beetle, <u>Leptinotarsa decemlineata</u> and its internal parasite <u>D. doryphorae</u>. Fourth instar beetle larvae were much more tolerant than were the 3rd instars. Neither fertility nor the ability to parasitize beetle larvae was adversely affected.

On the contrary Ball and Su (1980), demonstrated that the females of *Diabrotica virgifera* treated with sublethal doses of carbofuran and carbaryl Oviposited significantly more and lived significantly longer than did the control females.

In comparative tests individuals of a malathion resistant strain of rice weevil, *Sitophilus oryzae* laid fewer eggs over a 30-day period and produced fewer adult progeny than the control sample of susceptible individuals. However no difference was recorded in duration of preimaginal development (Bansoda and Bhatia, 1982).

Nielson (1983) evaluated the comparative toxicity of insecticides to adult black wine weevil, *Otiorhynchus qulcatus*. He found out that technical carbofuran was most toxic at 0.01% concentration via contact and ingestion to the adults. Beudicarb was next most effective at 0.1% and caused 90% mortality when applied topically. Acephate proved to be non toxic on topical application. Carbaryl and chlorpyrifos were relatively non toxic via all exposure modes. Permethrin and fenvalerate caused knock down within 1 and 2 hrs respectively.

Van Mallaert *et al*. (1984) evaluate insecticidal activity of 5-methoxy-6-(1-(4-methoxyphenyl) ethyl)-1, 3-benzodioxole, against the colarado potato beetle, *Leptinotarsa decemlineata*. After application larvae stopped feeding and died at concentration 50 ppm. At 25 ppm most larvae were unable to pupate and died as prepupae. Complete mortality occurred at 250 ppm. Reduction of egg hatch occurred at concentration as low as 10 ppm.

Diptera:

Very little work on the fecundity, fertility and mortality of Dipteron insect has been done so for.

Pree (1980) studied the toxicity of some insecticides to eggs and larvae of the apple maggot, *Rhagoletis pomonella* in the laboratory. Fenthion and Aziophosmethyle were more ovicidal than phosalone, phosmet, or dimethoate. Larval emergence was reduced in apples dipped at regular intervals after egg laying, in suspensions of fenthion, azinophosmethyl, or dimethoate, little or no larval feeding was found in first dipped in fenthion or azinophasmethyl 2 days after eggs were laid.

Nutrition is one of the important exogenous factor which influence growth and reproduction of insects. In insects the role of nutritive substances such as proteins, carbohydrates, fats, amino acids, vitamines and salts was studied on the growth and reproduction including fecundity and fertility of several species. In view of diverse feeding habits, food selection and biology, it was not possible to generalize the growth and reproduction of any particular order. Some of the important information on the role of food in controlling growth and reproduction of insects is reviewed in the following lines.

Orthoptera:

McCaffery (1976) studied that the oocyte development is not initiated when female *L. migratoria migratoroides* were fed on low-protein *Agropyson repens* (Gramineae). Survival on this diet was improved by the provision of water and small quantities of lush *A. repens*. The final percentage of terminal oocyte resorption and the possibility of oviposition was determined by the total quantity of food during vitelogensis. When the quantity of food ingested was reduced, the rate of oocytes development was first reduced, followed at lower level of feeding by an 'increase in TOR. Ingestion of L 80 mg (dry weight) of grass per female per day was insufficient to initiate oocyte development in locusts whose somatic growth period was normal.

Lepidoptera:

Woolever and Pipa (1970) observed that if the larvae of G. mellonella were deprived of free space the emergence of pupae was delayed. The nutritional requirements for pupation, and emergence were also studied. The larvae pupated if provided with any one of the following substances: bees wax, palmitic acid, ceryl alcohol, myristyl ester of Palmitric acid, and nothing more. Pupation also occurred with mixture of cellulose, casine, glucose and glycerine.

Steward and Baker (1970) studied that larval period of M. sexta was 2 days longer when reared on tobacco leaves than when they were reared on artificial diet. Weights of larvae at the end of the 5th stadium and resulting pupae were approximately the same whether the larvae were reared on tobacco leaves or on artificial diet.

Hassanein et. al. (1973) studied that feeding of cotton leaves prolonged the larval period in Spodoptera exiqua, while feeding on potato leaves shortened it. Further, feeding on different crops did not affect the pupal period in the male, but feeding on cowpea leaves shortened the female pupal period whereas, oviposition period remained unaffected. On the other hand, feeding at cotton leaves stimulated the number of egg deposition by per female.

According to Patocka (1974) larvae of *I. viridana* showed higher mortality when fed on *Qu. petraea* than on *Qu. robur*. The 2 host species showed differences in sugar and tanin contents. Larvae of *Eups. tranversa* showed significantly higher mortality on the tree at the edge of the forest than on the one inside the forest. However, for the lymantriids inside the forest the mortality was significantly lower and the fecundity significantly higher when the twigs were two thirds ringed i.e. the conduction pathways were interrrupted and the leaves comes to contain more sugar than unringed twings..

Baker and Miller (1974) studied the development of all stages of *S. littoralis* under a range of constant and cycling temperatures and reported that development was faster on lucerne (*Medicago sativa*) than on 2 cultivars of chrysan-thenum, Taffeta and Fed Shoesmith.

Zaazou *et al*. (1974) studied that when larvae of *Agrotis ipsilon* were reared on berseen, the larval duration shortened by 11.6 days than those reared on chick pea leaves. All Ist instar larvae reared on maize leaves died after 8 days while 20% of those reared from the 4th instar on such leaves survived and pupated. Ist and 4th instar larvae reared on fenngreek died after 4-7 days. The larval duration were clearly correlated with the percentages of water content and crude protein. In the case of pupae, one-day old weights were highly affected by larval food plant weight declining in order caster oil lucerne > cotton > chick pea > Egyptian lupin. Adult longevity was also affected by the larval food.

Dube and Chand (1978) reported that the development of Plutella xylostella on 5 food plants (all cruciferon) showed that duration of larval and pupal periods as well as percentage of individuals reaching adult stage varied. Radish and knol knol proved to be unfavourable foods as compared to cauliflower, cabbage and mustard.

Abdel-Fallah et.al. (1978) observed that lettuce, sweet potato, caster oil, cowpea and cabbage proved to be the most favourable larval food for S. litoralis due to high content of total carbohydrate, total nitrogen and essential growth elements. On these host plants the shortest larval and pupal periods, the heaviest pupae, the longest adult life span and the highest number of eggs were obtained. Contrary to the preceeding were kidney bean, berseems, broad bean, tomato, potato squash and taro.

Raina and Bell (1978) observed the effects of 4 treatments involving feeding of adult of Pink bollworms Pectinophora gossypiella on reproduction and diapouse response in resulting larval progeny. Mating and egg laying were significantly lower in moths which were starved or given only water compared with those fed on 10% sucrose or 10% honey solution. Egg hatching was lower on starved adults than those who were fed on 10% honey. There were no significant differences in the diapouse response of larval progeny from different treatments.

Senapati et. al. (1979) studied the growth and development of Earias vitella on fruit and shoot of okra and boll and shoot of cotton at incubation temperature of 29 $\pm$ 2^{o}C and room temperature of 32.30 $\pm$ 0.8^{o}C maximum and 30.80 $\pm$ 0.6^{o}C minimum. The best growth and shortest duration of development were obtained on okra fruit as larval food. On cotton shoot the growth of larvae and pupae was poorest and the duration of larval period was longest. The larva developed on okra fruits was 4.720 times greater and 2.344 times longer and the pupae 1.707 times greater and 1.273 times longer than the larvae and pupae developed in okra shoots. Similarly, the larvae and pupae reared on cotton boll were 5.006 and 1.957 times heavier and 2.104 and 1.278 times longer than the larvae and uppae reared on cotton shoots.

Latheef and Ortiz (1984) identified companion plants that repel imported cabbage worn, Pieris rapae and cabbage looper, Trichoplusia ni or reduced their oviposition on cruciferous crops.

Hemiptera:

Seuge et. al. (1971) found that when the 2 species were reared on pre-irradiated food, the fecundity of Pseudoulacarpis pentagona was reduced by 42% and 32% of Pludia interpunctella.

According to Isman (1978) no significant correlation was found between cardenolide content and body weight or size of the adult of Oncopeltus fasciatus when reared on seeds of eight different species of milk weed.

Diptera:

According to Roubound (1922) and Glaser (1923), when the house-fly, M. domestica was deprived of water and given protein or sugar normal egg laying could not occur.

Townseed and Lucas (1940) observed that if the Drosophila females were fed on a synthetic diet mixed with soluble fraction of royal jelly there was an 60% increase in the egg production.

Webster and Stoffolano (1979) reported that a protein free diet given to Rhagoletis pomonella resulted in drastic reduction in ovarian and accessory gland development. However, mating behavior in the males was apparently not affected.

Coleoptera:

Fletcher and Long (1971) studied the influence of food odors on oviposition by Lasioderma servicorne and found 7-fold increase in egg deposition when odors of tobacco or whole wheat flour were used as oviposition stimulants.

Ali et. al. (1973) observed the influence of natural food on the development and reproduction rate of Lasioderma sessicorns / viz. Cotton seeds, meal, yellow maize, peas, horse bean, bean pods, aniseed, whole wheat, carrot, ginger, beet, Each diet was analysed for water content, crude protein, soluble carbohydrates, crude fibres, ether extract and ashes. Larval development was greatly accelerated on the first-5 food items each containing a high protein and carbohydrate content. Pupal development and longevity were correlated with fat reserves of the individual. Fecundity was significantly greater in ♀♀ reared on cotton seed meal (26.4% protein) than in those reared on bean pods (29.39% protein).

Hamalainen and Markkala (1973) studied the effect of type of food on fecundity in 3 successive generations of Coccinella septempunctata. The female laid on the average 1325, 1217 and 1882 eggs when fed on Acyrthosiphon pisum, the best food on which female fed was Macrosiphum rosae which laid eggs significantly earlier than those feed on *Myzus persicae*, and laid more than twice as many eggs. The ♀♀ which had been given living aphids laid on average more than twice as many eggs perday as those fed on frozen. On the contrary females fed on an artificial diet laid no eggs.

Singh and Liles (1973) find out that when newly-emerged adult *Rhyzopertha dominicus* were fed on wheat grains irradiated with 0, 80, 160 and 320 krad the difference between the control food and that irradiated with 80 krad was not significant, while there was a significant reduction in survival with grain exposed to 320 krad. the higher irradiation doses also caused significant suppression of egg production and low egg-viability.

Hassan and Augew (1976) performed that the periodic dissection of adult females of *Pantorhytis szentivangi* and showed that the reproductive system was immature at emergence. A diet which included young chapons or water shoots of theobroma cacao, was necessary to achieve sexual maturation which generally occurred in 60-75 days under laboratory condition.

Vonder Nahrung Joshi (1976) observed that *Oryzaephilus mercator* showed greater variation in egg-laying on different dried-fruit meals (apricot, cashew, almond, ground nut, coconut, fig, date and raisin) the shortest egg period was 4.1 days on almond and the highest 5.1 on apricot the egg mortality on various meals differed to only small extent (11.8 - 14.1%). The larval period ranged between 22.7 and 34.3 days. The larval mortality varied from 7.8% (almond) and 94.4% (raisin).

Chun and Chandrapal (1979) studied the effects of the amounts of food available to larvae and to adults in Palembus dermestoides. The quantities provided for larvae were 1, 2, 5, 10 mg/larvae/week but these were raised to 20, 50, 100, 200, 400 and 1000 mg/larvae/week. Scarcity of food prolonged larval developmental period, increased instar number, increased mortality, prolonged the preoviposition period and reduced future fecundity.

Sharma et al. (1980) studied the oviposition and development of O. oryzae on 10 high yielding varieties of pady carried out experiments at various combinations of temperature (18, 25 and 30°C) and relative humidity, (45, 60, 75, 80 and 90%) neither oviposition nor development were influenced by the size of seeds. According to growth index (long n/Av.) the varieties in increasing suitability were in the order Pankaj > Raghusal > Pusa -21 > Bala Ratna > Kaveri IR-20 > IR-24 > IET-1991 > Jaya.

Barratt and Campbell (1983) studied the female reproductive development and food plant selection by adult beetles of Odontria striata.

III. MATERIAL AND METHOD

1. Breeding and Maintenance of Stock Culture:

(a) *Dysdercus cingulatus* Fabr.

The adults of *Dysdercus cingulatus* were collected from the cotton field and maintained in rearing glass jars measuring 20 x 15 cms containing 2-3 cms thick layer of moist and loose sand at the bottom. These jars were kept at 30 $\pm$ 1°C and 70-80% relative humidity in a B.O.D. incubator. All the stages were daily fed on soaked and healthy cotton seeds. When females laid eggs, the insects were transferred to fresh jars. On hatching the nymphs were daily provided with soaked cotton seeds.

(b) *Spodoptera litura* Fabr.

Adults of *Spodoptera litura* were collected in night near the lamp posts in the Aligarh Muslim University Campus during August to October. Several pairs of adults were kept in separate circular rearing jars made of glass measuring 8"x4". The bottom of the jars was fitted with wet and loose sterilized sand which was about two inches in thickness. The tops of the jars were covered with muslin cloth which was tightly fixed by means of rubber bands. All the rearing jars were kept at 30 $\pm$ 1°C temperature and 70-80% relative humidity. The moths were fed on saturated glucose solution. For this purpose, a piece of sterilized cotton wool was wrapped around a micro-slide and it was soaked with the fresh sugar solution. This slide was obliquely placed against the jar wall. Freshly soaked slides was daily replaced. When the females laid eggs in the rearing jars. The moths were transferred to other rearing jars. Following the hatching of the eggs, young larvae were given tender caster leaves for feeding. The jars having larval stages were daily cleaned and fresh leaves were provided daily. The larvae pupated and as moths emerged from the pupae, these were transferred to other rearing jars to maintain a large population of all stages throughout the year at the controlled condition. From the stock culture, 5th instar larvae were sorted out and kept in separate breeding jars.

The present experiment included two aspects:
Section (A) newly moulted (one day old) 4th and 5th instar nymphs of *Dysdercus cingulatus* and newly emerged (one day old) 5th and 6th instar larvae of *Spodoptera litura* were treated with different concentrations of cythion. Section (B), to study the effect of different types of nymphal and larval food on growth and reproduction of *Dysdercus cingulatus* and *Spodoptera litura.* 100 newly hatched nymphs and larvae of first instar were kept in glass jars (21 cm x 15 cm) in four replicates each consisting of 25 individuals. Four different types of food viz,

seeds of Lady finger (*Abelmoschus esculantus*), ground nut (*Arachis hypogaea*), yellow corn (*Zea mays*) and caster (*Ricinus communis*) were given to *Dysdercus cingulatus* nymphs. An equal number of nymph were also given cotton seeds (*Gossypium hirsutum*) to compare the results. Similarly four different types of food viz., leaves of Pigeon pea (*Cajanus cajan*), grape (*Vitis vinifera*), Spinach (*Spinacia oleracia*) and cotton (*Gossypium hirsutum*) were given to the larvae of *Spodoptera litura*. An equal number of larvae were also given castor leaves (*Ricinus communis*) to compare the results.

2. Experimental procedure:

(i) Preparation of different concentrations of the insecticide for *Dysdercus cingulatus*:

Five dilutions of cythion viz: (a) 10 ppm, (b) 20 ppm, (c) 40 ppm, (d) 60 ppm and (e) 80 ppm were prepared. To make a stock solution 30 mg of cythion was dissolved in 300 ml of acetone. Thus 1 μl of this solution (S) contained 0.01 μg of cythion (i.e. 100 ppm). Then 80 ml of this solution(s) was raised to 100 ml by acetone to make (S_1) solution. Thus 1 μl of this solution (S_1) contain 0.008 μg cythion (i.e., 80 ppm). Similarly S_2 was prepared which had 0.006 μg cythion in 1 μl (i.e. 60 ppm) solution. In this way serial dilution further gave 0.004 μg, 0.002 μg and 0.001 μg of cythion (i.e., 40 ppm, 20 ppm, and 10 ppm respectively) in 1 µl of acetone solution respectively.

(ii) <u>Preparation of different concentrations of the insecticide for S. litura</u>:

Five doses of cythion viz., 10,000 ppm, 5000 ppm, 2500 ppm, 1250 ppm and 625 ppm were prepared which were selected on the basis of LC-50 value. To make a stock solution (S) first of all 2 gms of cythion was dissolved in 100 ml of acetone. Thus 1 µl of this solution (S) contained 20,000 ppm (2 µg) of cythion. Then 50 ml of this solution (S) were raised to 100 ml by adding 50 ml of acetone to make (S_1) solution. Thus 1 µl of this solution (S_1) contain 10,000 ppm (1 µg) of cythion. Similarly S_2 was prepared which had 5000 ppm of cythion in 1 µl. In this way serial dilution further gave 2500 ppm (0.25 µg), 1250 ppm, (0.125 µg) and 625 ppm (0.065 µg) of cythion in 1 µl of acetone solution respectively.

(iii) <u>Application of the insecticide</u> :

Each concentration was applied on one day old individual nymphs of 4th and 5th instar *Dysdercus cingulatus* and 5th and 6th instar larvae of *Spodoptera litura* separately by topical method with the help of a tuberculine syringe which was fitted into a microapplier. The topical application was made by applying each concentration of the insecticide on the lateral inter segmental membrane of pro and meso-thorax of the individuals.~~xxphxx~~ Similarly nymphs and larvae were treated with 1 μl acetone solution to serve as parallel control. Untreated nymphs and larvae of the corresponding stage and age were also maintained to compare the results. Each concentration was tested against 100 nymphs of 4th and 5th instar D. cingulatus and 5th and 6th instar larvae of Spodoptera litura by this method, in four replicates, each consisting of 25 nymphs & larvae at a time. The individuals treated with each concentration were kept in separate rearing jars, provided with fresh soaked cotton seeds and castor leaves daily and maintained at the earlier mentioned condition of the temperature and humidity.

3. Method for Observations:

Following the application of each concentration of the insecticide on 4th and 5th instar (one day old) nymphs of D. cingulatus and 5th and 6th instar larvae of S. litura. Observations were made on growth, moulting, metamorphosis, of individuals, fecundity and fertility of adult females emerged from the treated nymphs and larvae. The data were compared with those of acetone treated (control) and untreated ones. The selection of concentrations was made on the basis of LC-50 value. For determining LC-50 value of cythion its different concentrations 100 ppm, 80 ppm, 60 ppm, 40 ppm and 20 ppm) were applied on 100 individuals of 4th instar and the respective mortalities were 65, 52, 31, 22 and 07%. Thus 80 ppm gave the mortality approximately fifty percent and was therefore regarded as LC-50 for D. cingulatus. Whereas different concentrations (15,000 ppm 10,000 ppm, 5000 ppm, 2500 ppm and 1250 ppm were applied and the respective mortalities were 68%, 49%, 34%, 21% and 09% respectively. Thus 10,000 ppm gave the mortality approximately fifty percent and was therefore regarded as LC-50 for S. litura. For observations on the fecundity and fertility of the females which emerged from the treated nymphs and larvae, 6 females emerged from the treated nymphs of either 4th or 5th instar of D. cingulatus and 5th and 6th instar of S. litura were paired with equal number of normal males of corresponding age and stage. Each pair was kept in a separate rearing jar at the above mentioned controlled conditions. The number of eggs laid by each female was recorded. Then the pairs were transferred to fresh rearing jars. After hatching the nymphs and larvae were counted. The unhatched eggs were also counted. Similar observations were also made in control consisting of the males and females emerged from acetone-treated as well as untreated nymphs and larvae.

The observations were also made on the residual effect of this insecticide in the successive (F_1) generation. When eggs of the affected females hatched,100 nymphs and larvae were randomly isolated for further observations on the growth, moulting, mortality, metamorphosis, fecundity and fertility according to the above mentioned method. Similar observations were made in the parallel control.

4. Statistical Analysis:

The data were analysed statistically. Standard deviation (S.D.) was calculated by the following formula:

$$S.D. = \sqrt{\frac{\sum D^2}{n - 1}}$$

where, S.D. = Standard deviation

D^2 = Sum of square of the differences of mean value.

n = Number of observations.

On the basis of standard deviation (S.D.) standard error (S.E.) was calculated by the following formula:

$$S.E. = \frac{S.D.}{\sqrt{n}}$$

where, S.E. = Standard Error,

S.D. = Standard deviation

n = Number of observations.

For the significant test the following formula was applied (Bailey, 1959).

$$t = \sqrt{\frac{m_1 - m_2}{\frac{SD_1}{n_1} + \frac{SD_2}{n_2}}}$$

where t = Significant value

m_1 = Mean value of first set of observation

m_2 = Mean value of second set of observation

SD_1 = Standard deviation of first set of observations

SD_2 = Standard deviation of second set of observations

n_1 = Number of observation of first set

n_2 = Number of observation of second set.

The calculated 't' was compared with the tabulated 't' (Bailey, 1959) at 5% level. If the former value is higher than the later, the data are significant otherwise insignificant. The tabulated value of 't' at 5% level is 2.447.

IV. RESULTS AND OBSERVATIONS

Section A:

(1) Effect of Topical application of different concentration of cythion on the 4th instar nymphs of *Dysdercus cingulatus*:

Each of the concentration viz, 10 ppm, 20 ppm, 40 ppm, 60 ppm and 80 ppm of cythion was topically applied on 24 hours old 100 nymphs of 4th instar individually in four replicates, each consisting of 25 nymphs.

In the first set of 100 nymphs, each nymph was topically treated with 1 ul acetone. No significant effect was found when compared to untreated nymphs. Out of 100 treated nymphs 3 nymphs died during the same instar whereas death of 1 nymph occurred at the ensuing ecdysis. Later, 2 nymphs died during the 5th instar and one died at the following nymphal adults moulting. Thus the total loss up to adult emergence was same as that of the untreated nymphs (Table - 1). The females emerged from such treated nymphs when mated with normal males laid almost equal number of eggs to those emerged from the untreated nymphs. Similarly there was no significant effect on the fecundity ($t = 0.972$, $p > 0.05$) and fertility ($t = 1.127$, $p > 0.05$), Table - 2.

In the next generation (F_1) of the acetone treated 4th instar nymphs, adult emergence was insignificantly reduced by 7% which was only 2% more than that in untreated nymphs

(9%, Table - 3). The effect on fecundity ($t = 1.166$, $p > 0.05$) and fertility ($t = 0.816$, $p > 0.05$) was also insignificant (Table - 4).

In the second set of 100 nymphs, each 4th instar nymph was topically treated with 10 ppm solution of cythion/nymph. Subsequently 3 nymphs died during the same instar, and one nymph died at the nymphal-adult moulting. The number of adults emerged from such treated nymphs was 3% more than that of the control, i.e. acetone treated nymphs (Table - 1) which was insignificant. Each of the affected female on average laid 3% eggs less than the control ones but the difference was statistically insignificant ($t = 1.129$, $p > 0.05$). Similarly reduction in the fertility of the eggs laid by the affected females was insignificant ($t = 0.587$, $p > 0.05$) (Table - 2).

In F_1 generation of the above treated insects total nymphal mortality upto adult emergence was 6% as compared to 7% in case of control (Table 3). The affected females of F_1 generation on the average laid almost equal number of eggs as compared to control. Thus there was no significant effect on the fecundity of such females ($t = 0.548$, $p > 0.05$). Fertility of eggs ($t = 0.751$, $p > 0.05$) was also not affected significantly as compared to that of the control (Table-4)

In the third set of 100 4th instar nymphs which were individually applied with 20 ppm solution of cythion, one died during the same instar, 3 nymphs died during the 5th instar and one nymph died at nymphal adult ecdysis. Adult emergence was increased by 3% as compared to that of the control (Table - 1). The emerged females (affected) on the average laid 3.05% less eggs than that of the control ($t = 1.580$, $p > 0.05$) which was insignificant. Similarly, the fertility remained unaffected as compared to the control ($t = 2.633$, $p > 0.05$, Table - 2).

In F_1 generation total nymphal mortality up to adult emergence was only 1 percent less than that in the control (Table - 3). Effect on fecundity ($t = 0.933$, $p > 0.05$) and fertility of eggs ($t = 1.546$, $p > 0.05$) were insignificant as compared to control (Table-4).

In the fourth set of 100 4th instar nymphs which were treated with 40 ppm solution of cythion/nymphs, 26 individuals died during the same instar and one could not survive at the ensuing nymphal moulting. Mortality during the 5th instar was of 8 nymphs and that of one at nymphal-adult ecdysis. Thus total fall in adult emergence was 29% more as compared to the control (Table - 1). Fecundity of the females emerged from the treated nymphs was insignificantly affected (4.56% reduction) as compared to control ($t = 1.988$, $p > 0.05$). Whereas, reduction in the fertility was significant ($t = 3.170$, $p < 0.05$) (Table-2)

In the F_1 generation total nymphal mortality was insignificant (5%) as compared to that (7%) in the control (Table - 3). Effect on fecundity ($t = 1.198$, $p > 0.05$) and fertility ($t = 1.322$, $p > 0.05$) was also statistically insignificant as compared to control (Table-4).

In the 5th set of 100 nymphs of 4th instar which were topically treated with 60 ppm solution of cythion/nymph. The number of nymphs which died during the 4th and 5th instar was 42 and 6 respectively. The total loss (48%) up to adult emergence being more than that (7%) in control (Table - 1). In comparision to control, fecundity of the females emerged from the treated 4th instar nymphs droped by 6.08% which was statistically insignificant ($t = 2.397$, $p > 0.05$). However, reduction in fertility was significant ($t = 4.349$, $p < 0.05$) as compared to control (Table -2)

In the F_1 generation of treated as well as control the total nymphal mortality up to adult emergence was equal (Table - 3). The effect on the fecundity ($t = 1.370$, $p > 0.05$) and the fertility ($t = 1.852$, $p > 0.05$) of the affected females was statistically insignificant (Table -4)

In the sixth set, each nymph was topically treated with 80 ppm concentration solution of cythion. Out of 100 treated nymphs at the 4th instar, 53 died during the same instar. In the later instar and than at the next moulting, mortality was 3 and 01 respectively. The fall in adult emergence was 50% as compared to that in control (Table - 1). The affected females on the average laid 7.59% eggs less than those by the control females which was statistically insignificant ($t = 2.517$, $p > 0.05$). Where as reduction in the fertility of the eggs laid by such females ($t = 5.016$, $p < 0.05$; Table) was significant as compared to that of control (Table - 2).

In the F_1 generation loss up to adult emergence was 08% as compared to 07% in the control (Table - 3). Fecundity of the affected females declined by 2.6% which was statistically insignificant ($t = 1.512$, $p > 0.05$). Similarly, fertility dropped by 2.19% which was also insignificant ($t = 2.176$, $p > 0.05$) as compared to control (Table-4).

(ii) <u>Effect of topical application of different concentration of cythion on the 5th instar nymphs of *Dysdercus cingulatus*</u>:

As mentioned earlier, each of the selected sub-lethal concentrations of cythion were also topically applied on 100 nymphs of 5th instar (24 hours old) of *Dysdercus cingulatus* individually in four replicates, each consisting of 25 nymphs.

In the first set of each of 100 nymphs was topically treated with 1 μl acetone only. It was observed that 3 nymphs died during the same 5th instar. Total nymph mortality was only 2% more than that of the untreated nymphs (Table - 5). The females emerged from these acetone treated nymphs did not exhibit significant change either in the fecundity ($t = 1.342$, $p > 0.05$) or fertility ($t = 1.283$, $p > 0.05$) as compared to those untreated nymphs (Table-6).

In the F_1 generation of acetone-treated 5th instar nymphs the total nymphal mortality up to adult emergence was 1% more than that of the untreated nymphs (Table-7). Similarly the fecundity ($t = 0.796$, $p > 0.05$) and fertility ($t = 0.574$, $p > 0.05$) of the females of F_1 generation were unaffected (Table - 8).

In the second set each 5th instar nymph was applied with 10 ppm concentration of cythion. Out of these 100 treated nymphs, 5 died during the same instar. The loss in the number of adults emerged from the treated nymphs was 2% more than that of the control i.e., acetone-treated (Table- 5). There was 0.53% fall in the fecundity of the affected females which was statistically insignificant ($t = 1.321$, $p > 0.05$). Similarly the effect on fertility was also insignificant ($t = 1.276$, $p > 0.05$) Table-6 .

In the F_1 generation total loss up to adult emergence was 3% less than that of the control (Table-7). There was no significant effect on either fecundity ($t = 1.112$, $p > 0.05$) or fertility ($t = 1.329$, $p > 0.05$) as compared to control (Table-8).

In the third set of 100 nymphs when each nymph was topically treated with 20 ppm concentration of cythion, 6 nymphs died during the same instar. The total nymphal mortality in the treated nymphs was 3% more than that of the control i.e. acetone-treated (Table-5). The affected females on the average laid 3.02% less eggs than that of the control which is insignificant ($t = 1.868$, $p > 0.05$). Whereas, reduction in the egg fertility ($t = 2.627$, $p < 0.05$) was significant (Table-6).

In the F_1 generation nymphal mortality was 1% less than that of the control (Table-7). The effect on the fecundity ($t = 1.717$, $p > 0.05$) and fertility ($t = 1.720$, $p > 0.05$) were insignificant (Table-8).

In the fourth set each nymph was applied with 40 ppm concentration of cythion. It was followed by mortality of 12 and 02 nymphs in the same instar and at the ensuing nymphal-adult moulting respectively. Fall in the number of emerged adults from the treated nymph was 11% more than that of the control i.e. acetone-treated nymphs (Table - 5). The average number of eggs laid by the affected females was 5.51% less than that of the control. Thus the fall in the fecundity was insignificant ($t = 2.451$, $p < 0.05$) whereas that of fertility was significant ($t = 4.261$, $p < 0.05$) as compared to respective controls (Table - 6).

In the F_1 generation the number of nymphs which died before emerging to adults was equal to that in affected nymphs as in the control (Table - 7). The females of F_1 generation did not exhibit significant change in either fecundity ($t = 1.455$, $p > 0.05$) or fertility ($t = 1.571$, $p > 0.05$) as compared to control (Table - 8).

In the fifth set of 100 nymph of 5th instar, topically treated with 60 ppm concentration of cythion, 27 nymphs suffered mortality during the same instar and 02 could not survive at the following nymphal-adult moulting. Adult emergence dropped by 26% as compared to that of the control i.e. acetone-treated (Table - 5). The affected females on the average laid 7.5% less eggs than that of the control which was statistically significant ($t = 2.578$, $p < 0.05$). Similarly reduction in the fertility was also significant ($t = 5.44$, $p < 0.05$) (Table - 6).

In the F_1 generation total loss of nymphs up to adult emergence was 1% more than that of the control (Table - 7).

Fall in the fecundity ($t = 1.504$, $p > 0.05$) and fertility ($t = 1.955$, $p > 0.05$) were statistically insignificant as compared to the respective control (Table - 8).

In the sixth set, each of 100 nymphs of 5th instar was applied with 80 ppm concentration solution of cythion. It was followed by the death of 38 nymphs during the same instars whereas, 02 nymphs suffered mortality at the ensuing nymphal-adult ecdysis. Total loss of life up to adult emergence was 37% more in the treated nymphs than the control i.e. acetone-treated (Table - 5). The average fecundity of the affected females significantly decreased by 11.48% as compared to that of control ($t = 3.861$, $p < 0.05$). The reduction in the fertility was 22.07% as compared to the control which was also significant ($t = 5.337$, $p < 0.05$) Table - 6

In the F_1 generation total nymphal mortality was 3% more in the affected nymphs that in the control (Table -7). The affected females on the average laid less eggs than that of the control which was statistically insignificant ($t = 1.944$, $p > 0.05$) and the fertility ($t = 2.671$, $p < 0.05$) which is also insignificant statistically.

(iii) Effect of topical application of different concentration of cythion on the 5th instar larvae of *Spodoptera litura*:

Each of the concentration viz, 625 ppm, 1250 ppm, 2500 ppm, 5000 ppm and 10,000 ppm of cythion was applied on one day old individual larvae of 5th instar in four replicates, each consisting of 25 larvae. An equal number of larvae was treated with acetone (solvent) only to serve as control. Similarly, a set of 100 larvae of the same stage and age were maintained to compare its results with those of acetone treated (control).

In the first set of 100 larval each was topically treated with 1 μl acetone. The effect was insignificant when compared to untreated larvae. Out of 100 treated larvae 4 died during the same 5th instar whereas death of one larvae occurred at the ensuing instar. Out of 95 pupae 2 were inviable and finally 93 adults emerged out. Thus the total loss upto adult emergence was approximately same as of the untreated larvae (Table -13). The females emerged from such treated larvae laid almost equal number of eggs to those emerged from the untreated larvae. So, there was no significant effect either on the fecundity ($t = 0.392$, $p > 0.05$) or on fertility ($t = 1.098$, $p > 0.05$) Table -14

In the next generation (F_1) of the acetone treated 5th instar larvae the adult emergence was 2% more than that in untreated larvae (91%) Table -15 The effect on fecundity ($t = 0.893$, $p > 0.05$) and fertility ($t = 0.917$, $p > 0.05$) was also insignificant (Table - 16).

In the second set each of 100 5th instar larvae was treated topically with 625 ppm concentration of cythion. 6 larvae lost their lives in the 5th instar whereas, 2 died in the ensuing 6th instar. The number of adults emerged from such treated larvae was 2% less than that of the control, i.e. acetone treated larvae (Table -13) which was insignificant. Each of the affected females laid 4.72% egg less than the control ones. This difference was statistically insignificant ($t = 1.891$, $p > 0.05$). Whereas reduction in the fertility of the eggs laid by the affected females was significant ($t = 2.769$, $p < 0.05$) Table - 14.

In the F_1 generation of the above treated insects total larval mortality up to adult emergence was 9% as compared to 7% in case of control (Table -15). Fecundity of the affected females of F_1 generation were 0.24% less than that of the control. Thus there was no significant effect either on fecundity ($t = 0.932$, $p > 0.05$) or on fertility ($t = 1.093$, $p > 0.05$) of eggs, Table -16

In the third set of 100 larvae of 5th instar which were individually applied topically with 1250 ppm solution of cythion. 7 larvae lost their lives in the same 5th instar whereas the larva died in the next 6th instar. Finally 92 larvae pupated and emerged out into adult. Thus there was not pupal death. The affected females on the average laid 8.21% eggs less than the control females. The effect being insignificant ($t = 2.177$, $p > 0.05$) whereas, reduction in the fertility was significant as compared to the control ($t = 3.144$, $p < 0.05$) Table - 14

In the F_1 generation total larval mortality up to adult emergence was only 2% less than that in the control (Table -15). Effect on fecundity ($t = 0.625$, $p > 0.05$) and fertility ($t = 1.228$, $p > 0.05$) were statistically insignificant as compared to control (Table -16).

In the fourth set of 100 5th instar larvae each was treated with 2500 ppm concentration of cythion solution. 19 larvae died during the same instar and one could not survive in the ensuing instar. Finally 80 larvae pupated out of which 78 emerged into adults. Thus 2 individuals died in pupal stage. The total fall in adult emergence was 15% more as compared to the control (Table -13). Fecundity of the females emerged from such treated larvae reduced by

15.49% as compared to control which was significant ($t = 3.306$, $p < 0.05$). Similarly, reduction in the fertility by 13.79% was also significant ($t = 4.770$, $p < 0.05$) Table -14.

In the F_1 generation total larval mortality was 10% as compared to that 7% in the control which was insignificant (Table -15). Effect on fecundity ($t = 1.225$, $p > 0.05$) and fertility ($t = 2.010$, $p > 0.05$) was also found to be statistically insignificant as compared to contsol (Table -16).

In the 5th set of 100 5th instar larvae, each was topically treated with 5000 ppm solution of cythion. The nymber of larvae which died in 5th instar and 6th instar were 41 and 03 respectively. The death of 2 individuals occurred in the pupal stage. Thus finally 54 pupae emerged into adults. The total loss up to adult emergence was 39% more than that in control (Table -13). In comparison to control, fecundity of the females emerged from the treated 5th instar larvae droped by 19.24% and this reduction was statistically significant ($t = 3.166$, $p < 0.05$). Similarly reduction in fertility was also significant ($t = 5.256$, $p < 0.05$) as compared to control (Table -14).

In the F_1 generation of such treated larvae total larval mortality was 2% more than that in control (Table -15). The effect on the fecundity ($t = 1.377$, $p > 0.05$) and fertility ($t = 2.196$, $p > 0.05$) of affected females was statistically insignificant.

In the sixth and last set, each of 100 larvae of 5th instar was topically treated with 10,000 ppm concentration solution of cythion. Out of 100 larvae 55 died in the same 5th instar and 02 could not survive in the next 6th instar. Thus 43 larvae pupated out of which 40 emerged into adults. The total fall in adults emergence was 53% more than that in control (Table -13). The affected females on the average laid 22.54% eggs less than the control ones. Thus loss in fecundity was statistically significant ($t = 3.529$, $p < 0.05$) Similarly reduction in fertility of the eggs laid by such females was also significant ($t = 5.449$, $p < 0.05$) as compared to that of control (Table -14).

In the F_1 generation total loss up to adult emergence was 11% as compared to 07% in the control (Table -15). Fecundity of the affected females reduced by 2.81% which was statistically insignificant ($t = 1.843$, $p > 0.05$). Similarly fertility dropped by 2.15 which was also insignificant ($t = 2.199$, $p > 0.05$) as compared to control (Table -16).

(iv) Effect of topical application of different concentration of cythion on the 6th instar larvae of *Spodoptera litura*:

As mentioned earlier, different concentrations of cythion were applied topically on 6th instar larvae (24 hrs. old) of *Spodoptera litura* individually in four replicates, each consisting of 25 larvae.

In the first set, each of 100 larvae was topically treated with 1 µl acetone solvent. It was found that 2 larvae died during the same instar and 98 underwent pupation out of which 97 emerged into adults. Thus one pupae was inviable. Total larval and pupal mortality was only 2% less than that of the untreated larvae and pupae (Table -17). The females emerged from these treated larvae did not exhibit any significant change either in fecundity ($t = 0.642$, $p > 0.05$) or fertility ($t = 1.050$, $p > 0.05$) as compared to those which emerged from untreated larvae (Table -18).

In the F_1 generation of acetone treated 6th instar larvae, the total larval mortality up to adult emergence was 1% less than that of the untreated larvae (Table19). Similarly fecundity ($t = 0.468$, $p > 0.05$) and fertility ($t = 1.930$, $p > 0.05$) of the females of F_1 generation were unaffected (Table -20).

In the second set of 100 larvae each of which was topically treated with 625 ppm concentration of cythion, 6 larvae could not survive in the same 6th instar. Whereas no death occurred in the pupal stage. Finally 94 pupae emerged into adults. The total larval mortality in the treated larvae was 3% more than that of the control i.e. acetone treated (Table -17). The affected females on average laid 3.27% less eggs than the control which was insignificant ($t = 1.755$, $p > 0.05$). Similarly effect on the fertility of eggs ($t = 2.437$, $p > 0.05$) was also insignificant (Table-18).

In the F_1 generation larval mortality was 1% more than that of the control (Table -19). The effect on the fecundity ($t = 1.009$, $p > 0.05$) and fertility ($t = 1.321$, $p > 0.05$) were statistically insignificant (Table-20).

In the third set each 6th instar larvae was applied topically with 1250 ppm concentration of cythion out of these 8 larvae died in the 6th instar. Remaining 92 larval pupated out of which 3 pupae were inviable and finally 89 emerged into adults. The loss in the number of adults emerged from such treated larvae was 8% more as compared to that of the control (Table -17). There was 5.07% fall in the production of eggs by affected females which was statistically insignificant ($t = 2.227$, $p > 0.05$) whereas effect on fertility was significant ($t = 3.315$, $p < 0.05$, Table -18).

In the F_1 generation total loss upto adult emergence was 2% more than that of the control (Table-19). There was no significant effect either on fecundity ($t = 0.746$, $p > 0.05$)

or on fertility ($t = 0.316$, $p > 0.05$) as compared to control (Table-20).

In the fourth set of 100 larvae each of which was topically treated with 2500 ppm concentration of cythion, 14 died in the same instar. Finally out of 86 pupae 84 emerged into aadult. Thus 2 individuals died in pupal stage. The total mortality up to adult emergence was 13% more than that of the control (Table -17) the affected females on the average laid 10.28% less eggs than the control and these doses was statistically significant ($t = 3.041$, $p < 0.05$). Similarly, reduction in the fertility of eggs ($t = 4.589$, $p < 0.05$) was also statistically significant (Table-18).

In the F_1 generation larval mortality was 2% more than that of the control (Table -19). The effect on the fecundity ($t = 1.490$, $p > 0.05$) and fertility ($t = 2.394$, $p > 0.05$) were insignificant (Table -20).

In the fifth set, 100 6th instar larvae were individually treated with 5000 ppm concentration solution of cythion. It was followed by the death of 34 larvae during the same instar, whereas death of 3 individuals occurred in the pupal stage. Thus finally 63 adults emerged out. Total oss of life up to adult emergence was 34% more in the treated larvae than the control i.e. acetone treated (Table -17). The average fecundity of the affected females significantly decreased (12.85) as compared to that of control ($t = 3.486$, $p < 0.05$). The reduction in the fertility was 13.26% which was also significant ($t = 4.776$, $p < 0.05$, Table-18).

In the F_1 generation total mortality was 1% more in the affected larvae than that in the control (Table-19). The affected females on the average laid 2.37% less eggs than the control. The loss was statistically insignificant ($t = 1.353$, $p > 0.05$). Similarly effect on fertility ($t = 1.914$, $p > 0.05$) was also insignificant.

In the sixth set of 100 larvae of 6th instar each of which was topically treated with 10,000 ppm concentration of cythion, 42 larvae suffered mortality during the same instar and 58 reached into pupal stage. Out of 58 pupae 57 emerged out into adult stage. One pupae being inviable. Adult emergence dropped by 40% as compared to that of the control (Table -17). The affected females on the average laid 17.77% less eggs than the control and this reduction was statistically significant ($t = 3.641$, $p < 0.05$), similarly reduction in the fertility was also significant ($t = 5.395$, $p < 0.05$), Table-18.

In the F_1 generation total loss of larvae and pupae up to adult emergence was 2% more than that of the control (Table -19). Fall in the fecundity ($t = 1.534$, $p > 0.05$) and fertility ($t = 2.229$, $p > 0.05$) were statistically insignificant as compared to respective control (Table - 20).

Section B

(i) Effect of feeding different types of food on growth and reproduction of *D. cingulatus*:

Each of the food viz. seeds of lady finger (*Abelmoschus esculantus*), ground nut seed (*Arachis hypogaea*), yellow corn (*Zea mays*) and castor (*Ricinus communis*) were supplied to the newly hatched nymphs in four replicates, each consisting of 25 nymphs. An equal number of nymphs was also given cotton seeds (*Gossypium hirsutum*) as to compare the results.

In the first set, 100 newly hatched nymphs were daily provided with soaked cotton seeds (*Gossypium hirsutum*). One nymphs died in the first instar, whereas all nymph survived in the second instar. In the 3rd instar 4 nymphs died and 95 moulted into 4th instar. Out of these 3 nymphs could not survive in the 4th instar and 92 reaches to the 5th instar. Finally one nymphs died in the 5th instar and thus 91 emerged into adults. The average longevity of 1st, 2nd, 3rd, 4th and 5th instar nymphs was 2 days, 4 days, 3 days and 5 days respectively. The average weights of 1st, 2nd, 3rd, 4th, 5th instar nymphs and that of adults were 0.45 mg, 1.50 mg, 5.13 mg, 15.39 mg, 48 mg and 61 mg respectively. The females emerged from such nymphs on the average laid 185 eggs out of which 97.27% hatched.

In the second set of 100 newly hatched nymphs, soaked seeds of Lady finger (Abelmuschus esculantus) were given daily. All the 100 nymphs during the first instar survived. However, 2 nymphs died in the second instar thus leaving 98 to reach into 3rd instar. In the 3rd instar 5 nymphs died and 93 nymphs moulted into 4th instar out of which one died in the same instar and 92 reaches into 5th instar. Lastly in the 5th instar 8 nymphs died. Thus 84 nymphs emerged into adults. The number of adults emerged from the nymphs fed on lady finger seeds was 7% less than those emerged from the nymphs which were given cotton seeds (control), Table - 9. The average longevity was same on the lady finger seeds as in the control (Table -11). The average weight of 1st, 2nd, 3rd, 4th, 5th instar nymphs and adults were 0.43 mg, 1.46 mg, 5.01 mg, 14.02 mg, 45.4 mg and 60 mg/nymphs respectively (Table -12). Each of the affected females on the average laid percent eggs less than the control and this reduction in the fecundity is statistically significant ($t = 5.564$, $p < 0.05$). Similarly reduction in the fertility of the eggs laid by the females was percent which was also significant ($t = 6.690$, $p < 0.5$)

In the third set, 100 newly hatched nymphs were offered soaked seeds of ground nut (Arachis hypogaea). 4 nymphs died in the 2nd instar 12 in the 3rd instar, thus 84 nymphs moulted into 4th instar. 25 nymphs could not survive in the 4th instar. 25 nymphs could not survive in the 4th instar and 18 died in the 5th instar. Finally 41 nymphs emerged into adults. Thus total nymphal mortality upto adult emergence was 50% more than that of control. The longevity of 1st and 2nd instar nymphs was same as in case of control (2 and 6 days respectively), whereas in the 3rd and 4th instar the longevity increased by 16 days and 17 days respectively as compared to the control (Table -11). In the 5th instar the longevity was 18 days more than of the control. The average weights of 1st, 2nd, 3rd, 4th, 5th instar nymphs and adults were 0.37 mg, 1.19 mg, 2.36 mg, 8.58 mg, 21.57 mg and 32.35 mg respectively which were approximately half as compared to those of control. The affected females laid percent less eggs than of the control ($t = 6.684$, $p < 0.5$). Similarly fertility were significantly reduced by percent ($t = 8.964$, $p < 0.5$).

In the fourth set of 100 newly hatched nymphs which were given unripped (milky stage) yellow corn seeds (Zea mays) daily, 2 nymphs died in the first instar. Out of the remaining 98 nymphs 2 nymphs again died in the 2nd instar and 11 died in the 3rd instar leaving 85 nymphs which moulted into 4th instar. Out of 85 nymphs 30 nymphs could not survive in the 4th instar and 20 nymphs of 5th instar succombed. Thus only 35 nymphs emerged into adults. The total nymphal mortality upto adults emergence in the nymphs fed on this diet was 56% more than that in control. The longevity of such nymphs was greater as compared to that of the cotton fed (control) nymphs. Longevities of 1st, 2nd, 3rd, 4th and 5th instar nymphs were 2 days, 5 days, 9 days, 13 days, and 17 days respectively as compared to 2 days, 4 days, 3 days, 3 days and 5 days respectively. The average weight/individual was also significantly reduced as compared to that of the control. The average weight of Ist, 2nd, 3rd, 4th, 5th instar nymph and adults were 0.39 mg, 1.35 mg, 3.10 mg, 10.27 mg, 24.4 mg and 38.27 mg/individual respectively. The females emerged from such nymphs laid percent egg less than of the control. Thus reduction in fecundity was significant ($t = 7.401$, $p < 0.5$) whereas fertility were also significantly reduced ($t = 9.335$, $p < 0.5$).

In the fifth set, 100 newly hatched nymphs were daily provided with soaked castor seeds (*Ricinus communis*). Three nymphs died in the 1st instar. Out of 97 nymphs which survived through the 1st instar 92 died in the 2nd instar thus only 5 nymphs reached in the 3rd instar. These 5 nymphs could not survive and died during the 3rd instar with in 24 hours. So on castor seeds all nymphs died up to 3rd instar and thus no adult emergence occurred. The average longevity of the 1st and 2nd instar of the affected nymphs were same as those of the control, 2 days and 4 days respectively. The average weights of 1st and 2nd instar nymphs were 0.34 mg and 0.86 mg per nymph respectively.

(ii) Effect of feeding different types of plant leaves on growth and reproduction of *Spodoptera litura*:

Newly hatched first instar larvae of *Spodoptera litura* were kept in glass jars (21 x 51 cm) and observations were made in four replicates each consisting of 25 larvae. The larvae were daily supplied with ample fresh food till they emerged as adults or died. The adults were reared on glucose solution. The quality of the leaves throughout the experiment remained the same. The leaves of four different types of plants viz. Pigeonpea (*Cajanus cajan*), Grape (*Vitis vinifera*), Spinach (*Spinacia oleracia*) and cotton (*Gossypium hirsutum*) were used for each experiment. An equal number of larvae were given leaves of castor (*Ricinus communis*) to serve as control. The observations were made on the survival, developing stage (longevity) as well as duration, weight, fecundity and fertility of the adult females.

In the first set, 100 newly hatched larvae were daily provided with fresh castor leave (*Ricinus communis*). All the

100 larvae survived through the 1st instar. In the 2nd instar 3 larvae lost their lives and 97 moulted to the 3rd instar. Out of these 97 one larva could not survive in the 3rd instar. Out of 96 larvae which are in the 4th instar 2 died. In the 5th instar 2 larvae lost their lives and remaining 93 moulted to the 6th instar. One larva died in the 6th instar and finally 92 underwent pupation. Out of 29 pupae 8 were inviable and 83 emerged into adults. Thus total mortality up to adult emergence was 10%. The average longevities for 1st, 2nd, 3rd, 4th, 5th, 6th instar larvae and pupae were 2 days, 3 days, 3 days, 3 days, 2 days, 3 days and 7 days respectively. The respective average weights of 1st, 2nd, 3rd, 4th, 5th and 6th instar larvae, pupae and adults were 14.8 mg, 31.2 mg, 72 mg, 193 mg, 391 mg, 871 mg, 357 mg and 120 mg. The females emerged from such pupae on the average laid 426 eggs, out of which 96.01% hatched.

In the second set of 100 newly hatched larvae, fresh leaves of Pigeonpea (Cajanus cajan) were given daily. 10 larvae died during the first instar whereas 12 could not survive in the ensuing (2nd instar) instar. In the 3rd instar 12 larvae died and 66 moulted to the 4th instar where 11 larvae last their life leaving 55 larvae which moulted into 5th instar. In the 5th instar 07 larvae last their lives and 48 larvae lost their lives and 48 larvae reached into the 6th instar out of which 6 died in this final (6th instar) stage.

Finally 42 larvae reached into pupation where 4 pupae were inviable resulting the emergence of 38 adults. The total mortality upto adult emergence is 52% more as compared to that of control. The average longevity was 2 days, 7 days, 5 days, 6 days, 6 days, 8 days and 7 days for the 1st, 2nd, 3rd, 4th, 5th, 6th instar larvae and pupae respectively (Table -23). Their corresponding average weights were 13 mg, 21 mg, 54.6 mg, 133 mg, 270 mg, 424 mg and 144 mg. The average weight of adults was 62 mg (Table -24). The affected females on the average laid 48.57% egg less than control and this reduction was statistically significant ($t = 7.549$, $p < 0.05$). Similarly reduction in the fertility of the eggs laid by such females was 38.35% which was also significant ($t = 10.059$, $p < 0.05$) Table-22.

In the third set, 100 newly hatched larvae were daily offered leaves of Grape (<u>Vitis vinifera</u>). In the 1st instar 8 larvae lost their lives and 92 reached to 2nd instar. In the 2nd instar 6 larvae died. Out of 86 larvae which are in 3rd instar, 04 died in this instar whereas 06 could not survive in the ensuing 4th instar which led 76 larvae to moult into 5th instar. Death of 3 and 5 larvae occurred during the 5th and 6th instar respectively. Thus remaining 68 individuals underwent pupation. Out of which 61 pupae emerged into adults, the remaining 7 pupae being dead. The total mortality up to adult emergence was 29% more as compared to control. The longevity of 1st, 2nd, 3rd, 4th, 5th, 6th instar larvae and pupae were 2 days, 4 days, 3 days, 3 days, 3 days, 6 days and 7 days respectively. The average weights of 1st, 2nd, 3rd, 4th, 5th, 6th instar larvae pupae and adults were 13.6 mg, 23 mg, 53 mg, 161 mg, 293 mg, 549 mg, 154 mg and 90 mg respectively. The affected females on the average laid 26.6% egg less than that of the control ($t = 5.469$, $p < 0.05$). Similarly fertility was also reduced (53.2%) significantly ($t = 9.741$, $p < 0.05$) Table -22.

In the fourth set of 100 newly emerged larvae which were daily given fresh leave of spinach (Spinacia oleracia). 04 larvae died in the 1st instar and 05 died in the ensuing 2nd instar. Out of the remaining 91 larvae which are in the 3rd instar 5 larvae again died during this and 2 larvae could not survive in the 4th instar. During the 5th instar 3 larvae died and out of 81 larvae of 6th instar one lost its life. Thus 80 individuals which pupated. Out of 80 pupae 8 pupae were inviable and 72 emerged into adults. Thus total mortality upto adult emergence was 28% which was 18% more than that in the control. The longevities of 1st, 2nd, 3rd, 4th, 5th, 6th instar larvae and pupae were 2 days, 3 days, 3 days, 4 days, 3 days, 5 days and 7 days respectively. The average weights of 1st, 2nd, 3rd, 4th, 5th, 6th instar larvae, pupae and adults were 13.7 mg, 27.2 mg, 62 mg, 171 mg, 319 mg, 726 mg, 215 mg and 92 mg respectively. The females emerged from such larvae on the average laid 14.55% eggs less than the control. This reduction in the fertility was significant ($t = 4.217$, $p < 0.05$). Similarly fertility was also significantly reduced ($t = 8.013$, $p < 0.05$) Table - 22.

In the fifth set, 100 newly hatched larvae were daily provided with fresh leaves of cotton (Gossypium hirsutum) 3 larvae died in the 1st instar. Out of 97 2nd instar larvae 01 died and 96 moulted into 3rd instar. 04 larvae could not survive in the 3rd instar and 2 lost their lives in the 4th instar. 3 larvae died during each of 5th and 6th instar. The remaining 84 larvae underwent pupation out of which 12 pupae were inviable. Finally 72 emerged into adults. Thus total loss upto adult emergence was 28% which was 18% more than the control. The average longevity of 1st, 2nd, 3rd, 4th 5th, 6th instar larvae and pupae were 2 days, 2 days, 3 days, 3 days, 3 days, 5 days and 6 days respectively (Table-23). The average weight of 1st, 2nd, 3rd, 4th, 5th, 6th instar larvae, pupae and adults were 14.2 mg, 29.3 mg, 89 mg, 189 mg, 374 mg, 818 mg, 208 mg, and 99 mg respectively. Each of the affected females on the average laid 6.57% egg less than the control. and this reduction was statistically significant ($t = 2.888$, $p < 0.05$). Similarly, reduction in the fertility of the eggs laid by such females was 14.86% which was also significant ($t = 5.583$, $p < 0.05$) Table - 22.

Table 1: Showing total nymphal mortality following the topical application of different concentrations of cythion on the 4th instar nymphs (24 hrs. old) Dysdercus cingulatus.

Concentrations (ppm)	Nymphal mortality				Total loss upto adult emergence
	4th instar	At moulting 4-5th	5th instar	At nymphal adult moulting	
10 ppm	03	-	-	01	04
20 ppm	01	-	03	-	04
40 ppm	26	01	08	01	36
60 ppm	42	-	06	-	48
80 ppm	53	-	03	01	57
Acetone (control)	03	01	02	01	07
Untreated	04	-	02	01	07

Total 100 treated nymphs/Conc.in 4 replicates of 25 each.

Table 2: Showing fecundity and fertility of *Dysdercus cingulatus* females emerged following the topical application of different concentrations of cythion on the 4th instar nymphs (24 hrs. old).

Concentrations (ppm)	No. of eggs laid (Mean $\pm$ S.E.)	No. of eggs hatched (Mean $\pm$ S.E.)	Percentage of hatching
10 ppm	195 $\pm$ 2.898	177 $\pm$ 4.04	90.76
20 ppm	190 $\pm$ 4.79	163 $\pm$ 2.38	85.78
40 ppm	187 $\pm$ 3.86	158 $\pm$ 2.00	84.49
60 ppm	184 $\pm$ 3.08	141 $\pm$ 1.92	76.63
80 ppm	181 $\pm$ 3.63	130 $\pm$ 1.81	71.82
Acetone	198 $\pm$ 2.36	178 $\pm$ 2.44	89.89
Untreated	200 $\pm$ 2.36	181 $\pm$ 2.82	90.50

Table 3: Showing nymphal mortality and adult emergence in F_1 generation following the topical application of different concentrations of cythion on the 4th instar nymphs (24 hr. old) of F generation of *Dysdercus cingulatus*.

Concentrations (ppm)	Nymphal mortality					Adult emergence	Total loss upto adult emergence
	Ist instar	2nd instar	3rd instar	4th instar	5th instar		
10 ppm	02	-	03	-	01	94	06
20 ppm	01	-	02	01	02	94	06
40 ppm	-	02	01	02	-	95	05
60 ppm	01	01	02	03	-	93	07
80 ppm	04	01	-	02	01	92	08
Acetone (control)	01	-	02	01	03	93	07
Untreated	02	03	01	01	02	91	09

Total 100 treated nymphs/Conc.in 4 replicates of 25 each.

Table 4: Showing fecundity and fertility of *Dysdercus cingulatus* females (F_1 generation) following the topical application of different concentrations of cythion on the 4th instar nymphs of F generation.

Concentrations (ppm)	No. of eggs laid (Mean ± S.E.)	No. of eggs hatched (Mean ± S.E.)	Percentage of hatching
10 ppm	193 ± 4.08	190 ± 4.17	98.44
20 ppm	192 ± 1.78	180 ± 3.74	95.83
40 ppm	190 ± 2.88	186 ± 3.92	97.89
60 ppm	189 ± 2.60	183 ± 2.12	96.82
80 ppm	186 ± 4.48	180 ± 1.92	96.77
Acetone (Treated)	194 ± 3.34	192 ± 3.74	98.96
Untreated	197 ± 1.58	194 ± 2.96	98.48

Table 5: Showing nymphal mortality and adult emergence following the topical application of different concentrations of cythion on the 5th instar nymphs (24 hrs. old) of *Dysdercus cingulatus*.

Concentrations	Nymphal mortality		Total loss upto adult emergence	Adult emergence
	5th instar	At nymphal-adult moulting		
10 ppm	05	00	05	95
20 ppm	06	00	06	94
40 ppm	12	02	14	86
60 ppm	27	02	29	71
80 ppm	38	02	40	60
Acetone treated	03	00	03	97
Untreated	01	00	01	99

Total 100 treated nymphs/concentration; 4 replicates of 25 each.

Table 6: Showing fecundity and fertility of _Dysdercus_ _cingulatus_ females emerged following the topical application of different concentrations of cythion on the 5th instars (24 hrs. old).

Concentrations (ppm)	No. of eggs laid (Mean $\pm$ S.E.)	No. of eggs hatched (Mean $\pm$ S.E.)	Percentage of hatching
10 ppm	196 $\pm$ 3.94	179 $\pm$ 2.98	91.32
20 ppm	191 $\pm$ 3.94	164 $\pm$ 3.64	85.86
40 ppm	186 $\pm$ 3.11	147 $\pm$ 1.92	79.03
60 ppm	182 $\pm$ 3.92	131 $\pm$ 1.41	71.97
80 ppm	174 $\pm$ 1.58	120 $\pm$ 2.82	68.96
Acetone (control)	201 $\pm$ 2.46	183 $\pm$ 2.50	91.04
Untreated	205 $\pm$ 2.48	188 $\pm$ 4.28	91.70

Table 7: Showing nymphal mortality and adult emergence in F_1 generation following the topical application of different concentrations of cythion on the 5th instar nymphs (24 hrs. old) of F generation of <u>Dysdercus cingulatus</u>.

Concentrations/ 1 ul/nymphs	Nymphal mortality						Adult emergence
	Ist instar	2nd instar	3rd instar	4th instar	5th instar	Total loss upto adult emergence	
10 ppm	-	03	01	01	-	05	95
20 ppm	01	02	01	03	-	07	93
40 ppm	-	02	02	01	03	08	92
60 ppm	02	01	-	03	03	09	91
80 ppm	02	03	01	03	02	11	89
Acetone treated	01	03	-	03	01	08	92
Untreated	04	-	02	01	-	07	93

Total 100 ist instar nymphs/concentration; 4 replicates of 25 each.

Table 8: Showing fecundity and fertility of *Dysdercus cingulatus* females (F_1 generation) following the topical application of different concentrations of cythion on the 5th instar nymphs of F generation.

Concentrations (ppm)	No. of eggs laid (Mean ± S.E.)	No. of eggs hatched (Mean ± S.E.)	Percentage of hatching
10 ppm	193 ± 2.94	189 ± 3.16	97.92
20 ppm	197 ± 1.79	192 ± 2.88	97.46
40 ppm	196 ± 1.00	190 ± 3.18	96.93
60 ppm	192 ± 4.61	186 ± 3.27	96.88
80 ppm	186 ± 4.59	180 ± 2.17	96.77
Acetone treated (control)	201 ± 4.28	197 ± 3.16	98.00
Untreated	203 ± 2.77	198 ± 3.62	97.54

Table 9: Showing effect of different types of food on the nymphal mortality of <u>Dysdercus</u> <u>cingulatus</u>.

Food/seeds	Ist instar		2nd instar		3rd instar		4th instar		5th instar		Adult emergence	Percentage mortality
	No.cf nymphs	Loss	No.of nymphs	Loss	No.of nymphs	Loss	No.of nymphs	Loss	No.of nymphs	Loss		
Lady fingers	100	00	100	02	98	05	93	01	92	08	84	16
Ground nut	100	00	100	04	96	12	84	25	59	18	41	59
Yellow corn	100	02	98	02	96	11	85	30	55	20	35	65
Castar	100	03	97	92	05	05	00	00	00	00	00	100
Cotton (control)	100	01	99	00	99	04	95	03	92	01	91	09

Table 10: Showing fecundity and fertility of _Dysdercus cingulatus_ females emerged following the different type of food.

Food	No. of eggs laid (Mean $\pm$ S.E.)	No. of eggs hatched (Mean $\pm$ S.E.)	Percentage of hatching
Lady finger	112 $\pm$ 3.082	92 $\pm$ 1.788	82.14
Ground nut	72 $\pm$ 3.464	22 $\pm$ 1.788	30.55
Yellow corn	42 $\pm$ 3.647	12 $\pm$ 1.703	28.57
Caster	-	-	-
Cotton (control)	185 $\pm$ 2.190	180 $\pm$ 2.608	97.27

Table 11: Showing nymphal longevity of <u>Dysdercus cingulatus</u> at different type of food (mean value)

Food	Ist instar	2nd instar	3rd instar	4th instar	5th instar
Lady finger	2 days	4 days	4 days	3 days	6 days
Ground nut	2 days	6 days	19 days	20 days	23 days
Yellow corn	2 days	5 days	9 days	13 days	17 days
Caster	2 days	- - - - - - - - - - All die - - - - - - - - - - - - - -			
Cotton (Control)	2 days	4 days	3 days	3 days	5 days

Table 12: Showing the nymphal and adult weight of <u>Dysdercus cingulatus</u> (Mean values).

Food	1st instar (wt. in mg)	2nd instar (wt. in mg)	3rd instar (wt. in mg)	4th instar (wt. in mg)	5th instar (wt. in mg)	Adults (wt. in mg)
Lady finger	0.43 ± 0.01	1.46 ± 0.02	5.01 ± 0.02	14.02 ± 0.42	45.40±0.01	60.0±0.03
Ground nut	0.37 ± 0.01	1.19 ± 0.01	2.36 ± 0.02	8.58 ± 0.04	21.57±0.05	32.35±0.03
Yellow corn	0.39 ± 0.01	1.35 ± 0.02	3.10 ± 0.02	10.27±0.03	24.40±0.01	38.27±0.01
Castar	0.34 ± 0.03	0.86 ± 0.03	-	-	-	-
Cotton (Control)	0.45 ± 0.03	1.50 ± 0.02	5.13 ± 0.02	15.39±0.03	48.00±0.03	61.00±0.03

Table 13: Showing total larval and pupal mortality following the topical application of different concentrations of cythion on the 5th instar larvae of *Spodoptera litura*.

Concentrations (ppm)	Mortality			
	5th instar larvae	6th instar larvae	pupae	Adult emergence
625 ppm	06	02	01	91
1250 ppm	07	01	-	92
2500 ppm	19	01	02	78
5000 ppm	41	03	02	54
10000 ppm	55	02	03	40
Acetone (control)	04	01	02	93
Untreated	05	-	01	94

Total 100 treated larvae/concentration, 4 replicates of 25 each.

Table 14: Showing fecundity and fertility of _Spodoptera litura_ females following the topical application of different concentrations of cythion on the 5th instar larvae (24 hrs. old)

Concentrations	No. of eggs laid	No. of eggs hatched	Percentage of hatching
625 ppm	407 $\pm$ 4.427	367 $\pm$ 4.539	90.17
1250 ppm	392 $\pm$ 8.124	331 $\pm$ 8.155	84.43
2500 ppm	361 $\pm$ 5.648	287 $\pm$ 6.025	79.50
5000 ppm	345 $\pm$10.406	267 $\pm$ 5.683	77.39
10000 ppm	331 $\pm$ 9.428	247 $\pm$ 6.442	74.52
Acetone (control)	426 $\pm$ 7.443	400 $\pm$ 5.079	93.89
Untreated	425 $\pm$ 7.092	405 $\pm$ 4.195	95.29

Table 15: Showing the larval and pupal mortality and adult emergence in F_1 generation following the topical application of different concentrations of cythion on the 5th instar larvae (25 hrs. old) of F generation of *Spodoptera litura*.

Concentrations (ppm)	Ist instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	Pupae	Adult emergence
625 ppm	01	01	02	00	02	01	02	91
1250 ppm	02	01	01	02	01	01	01	91
2500 ppm	00	02	03	01	01	02	01	90
5000 ppm	01	02	00	02	01	03	00	91
10000 ppm	03	00	02	01	02	02	01	89
Acetone (control)	01	00	03	01	01	00	01	93
Untreated	02	01	02	01	00	02	01	91

Table 16: Showing fecundity and fertility of *Spodoptera litura* females (F_1 generation) following the topical application of different concentrations of cythion on the 5th instar larvae of 'F' generation.

Concentrations (ppm)	No. of eggs laid (Mean ± S.E.)	No. of eggs hatched (Mean ± S.E.)	Percentage of hatching
625 ppm	423 ± 7.293	406 ± 5.595	95.88
1250 ppm	426 ± 5.857	405 ± 4.743	94.95
2500 ppm	421 ± 4.841	394 ± 4.324	93.43
5000 ppm	419 ± 5.030	388 ± 5.495	92.42
10000 ppm	412 ± 4.950	388 ± 5.468	94.02
Acetone (control)	428 ± 5.586	412 ± 5.630	96.17
Untreated	432 ± 5.630	416 ± 5.000	96.21

Table 17: Showing total larval and pupal mortality and adult emergence following the topical application of different concentrations of cythion on 6th instar larvae (24 hrs. old) _Spodoptera litura_.

Concentrations (ppm)	6th instar	Pupae	Adult emergence
625 ppm	06	00	94
1250 ppm	08	03	89
2500 ppm	14	02	84
5000 ppm	34	03	63
10000 ppm	42	01	57
Acetone (control)	02	01	97
Untreated	03	02	95

Total 100 treated larvae/concentration; 4 replicates of 25 each.

Table 18: Showing fecundity and fertility of <u>Spodoptera</u> <u>litura</u> females following the topical application of different concentrations of cythion on the 6th instar larvae (24 hrs. old).

Concentrations (ppm)	No. of eggs laid (Mean ± S.E.)	No. of eggs hatched (Mean ± S.E.)	Percentage of hatching
625 ppm	412 ± 5.630	377 ± 5.196	91.50
1250 ppm	400 ± 6.633	351 ± 5.814	87.75
2500 ppm	382 ± 5.128	313 ± 4.690	81.93
5000 ppm	371 ± 4.494	301 ± 5.128	81.13
10000 ppm	350 ± 7.162	278 ± 4.711	79.42
Acetone (control)	428 ± 5.991	404 ± 4.969	94.39
Untreated	430 ± 4.868	410 ± 7.190	95.34

Table 19: Showing the larval and pupal mortality and adult emergence in F_1 generation following the topical application of different concentrations of cythion on the 6th instar larvae (24 hrs. old) of F generation of <u>Spodoptera litura</u>.

Concentrations (ppm)	Ist instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	Pupae	Adult emergence
625 ppm	01	00	02	01	01	02	01	92
1250 ppm	00	02	01	00	03	01	02	91
2500 ppm	01	02	01	03	01	00	02	91
5000 ppm	02	01	02	01	00	01	01	92
10000 ppm	02	02	01	00	01	02	01	91
Acetone (control)	02	00	01	01	02	00	01	93
Untreated	02	01	00	02	01	01	01	92

Table 20: Showing the fecundity and fertility of *Spodoptera litura* females (F_1 generation) following the topical application of different concentrations of cythion on the 6th instar larvae of F generation.

Concentrations (ppm)	No. of eggs laid (Mean ± S.E.)	No. of eggs hatched (Mean ± S.E.)	Percentage of hatching
625 ppm	416 ± 5.630	400 ± 6.124	96.15
1250 ppm	418 ± 6.719	405 ± 5.941	96.88
2500 ppm	411 ± 4.732	383 ± 5.630	93.18
5000 ppm	412 ± 5.656	392 ± 5.648	95.14
10000 ppm	410 ± 5.118	386 ± 5.779	94.14
Acetone (control)	421 ± 5.339	408 ± 4.123	96.91
Untreated	420 ± 4.857	408 ± 4.207	97.14

able 21: Showing effect of different types of food on the larval and pupal mortality of *Spodoptera litur*

ood	Ist instar		2nd instar		3rd instar		4th instar		5th instar		6th instar		Pupae		Adult
	No.of larvae	Loss	No.of larvae	Loss	No.of larvae	Loss	No.of larvae	Loss	No.of larvae	Loss	No.of larvae	Loss	No.of larvae	Loss	
.geon pea	100	08	92	06	86	04	82	06	76	03	73	05	68	07	61
rape	100	10	90	12	78	12	66	11	55	07	48	06	42	04	38
inach	100	04	96	05	91	05	86	02	84	03	81	01	80	08	72
otton	100	03	97	01	96	04	92	02	90	03	87	03	84	12	72
astar	100	00	100	02	98	01	96	02	94	02	93	01	92	02	90

Table 22: Showing fecundity and fertility of _Spodoptera litura_ females emerged following the different types of food.

Food	No. of eggs laid (Mean $\pm$ S.E.)	No. of eggs hatched (Mean $\pm$ S.E.)	Percentage of hatching
Pigeon pea	219 $\pm$ 4.775	084 $\pm$ 3.912	38.35
Grape	313 $\pm$ 5.099	134 $\pm$ 3.209	42.81
Spinach	364 $\pm$ 4.450	208 $\pm$ 3.728	57.14
Cotton	398 $\pm$ 4.159	323 $\pm$ 2.898	81.15
Caster	426 $\pm$ 3.347	409 $\pm$ 3.271	96.01

Table 23: Showing larval and pupal longevity of *Spodoptera litura* at different types of food (mean value).

Food	Ist instar in days	2nd instar in days	3rd instar in days	4th instar in days	5th instar in days	6th instar in days	Pupae in day
Pegion pea	2	7	5	6	6	8	7
Grape	2	4	2	3	3	6	7
Spinach	2	3	3	4	3	5	7
Cotton	2	2	3	3	3	5	6
Caster	2	3	3	3	2	3	7

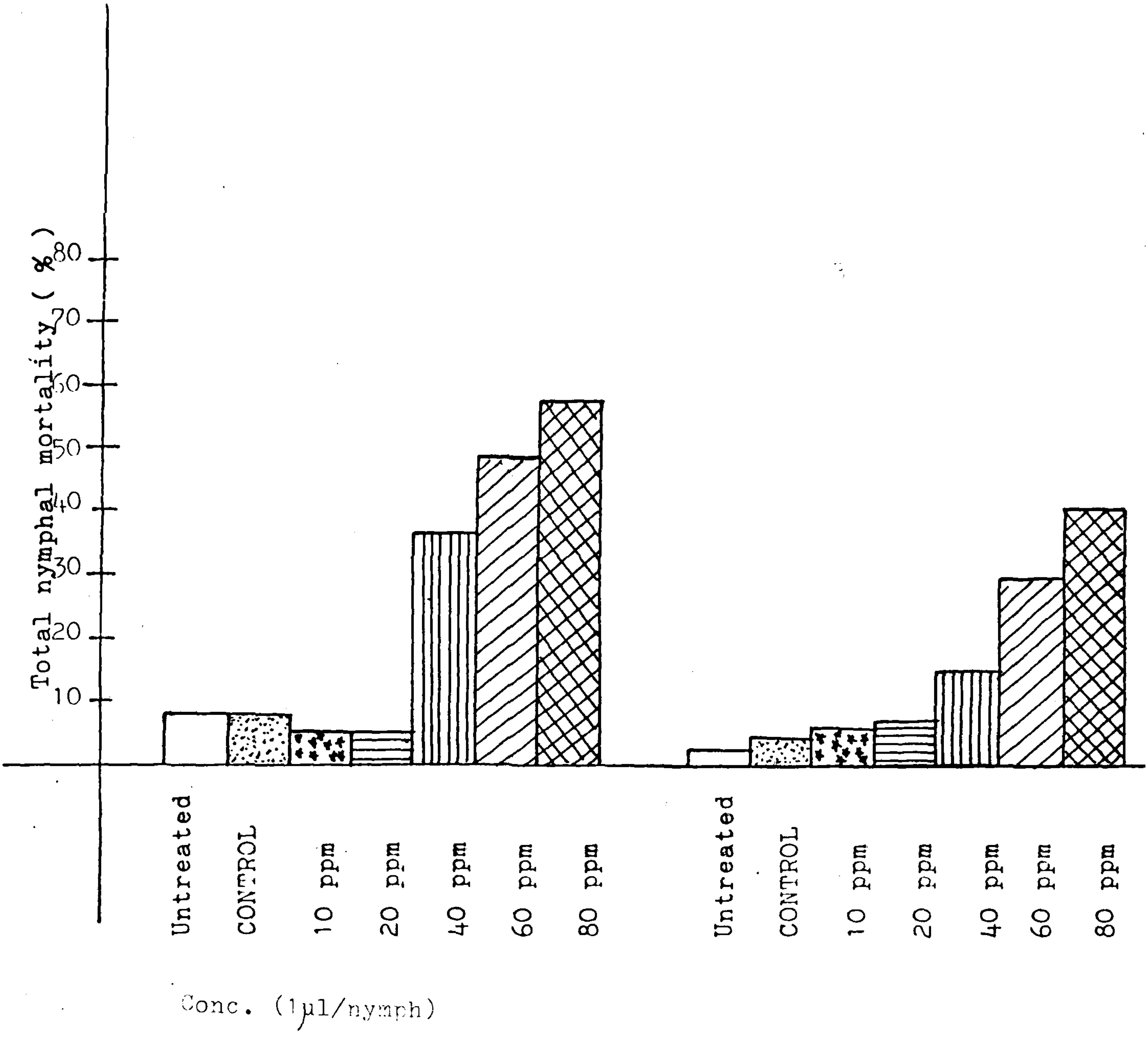
Table 24: showing larval, pupal and adult weight of *Spodoptera litura* (mean values).

Food	1st instar wt. in mg	2nd instar wt. in mg	3rd instar wt. in mg	4th instar wt. in mg	5th instar wt. in mg	6th instar wt. in mg	Pupae wt. in mg	Adults wt. in m
Pegion pea	13.0±0.451	21.0±0.493	54.6±0.482	133±0.635	270±0.636	424±0.636	144±0.636	62 ±0.72
Grapes	13.6±0.152	23.0±0.130	53.0±0.389	161±0.311	293±0.415	549±1.289	154±0.707	90 ±0.52
Spinach	13.7±0.494	27.2±0.321	62.0±0.638	171±0.429	319±0.738	726±0.581	215±0.473	108±0.35
Cotton	14.2±0.305	29.3±0.717	69.0±0.503	189±3.717	374±0.570	818±1.581	208±0.707	99±0.81
Caster	14.8±0.478	31.2±0.583	72.0±0.707	193±0.707	391±0.707	871±0.723	357±0.707	152±0.32

Fig. 1: Showing total nymphal mortality up to adult emergence following the topical application of different concentrations of cythion to the 4th and 5th instar nymphs of *Dysdercus cingulatus* respectively.

A= 4th instar nymphs..

B= 5th instar nymphs..



Total nymphal mortality (%)
80
70
60
50
40
30
20
10
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Conc. (1µl/nymph)

Fig. 2: Showing reduction in the fecundity of females *Dysdercus cingulatus* emerged following the topical application of different concentrations of cythion to the 4th and 5th instar nymphs respectively.

A= 4th instar nymphs.

B= 5th instar nymphs.

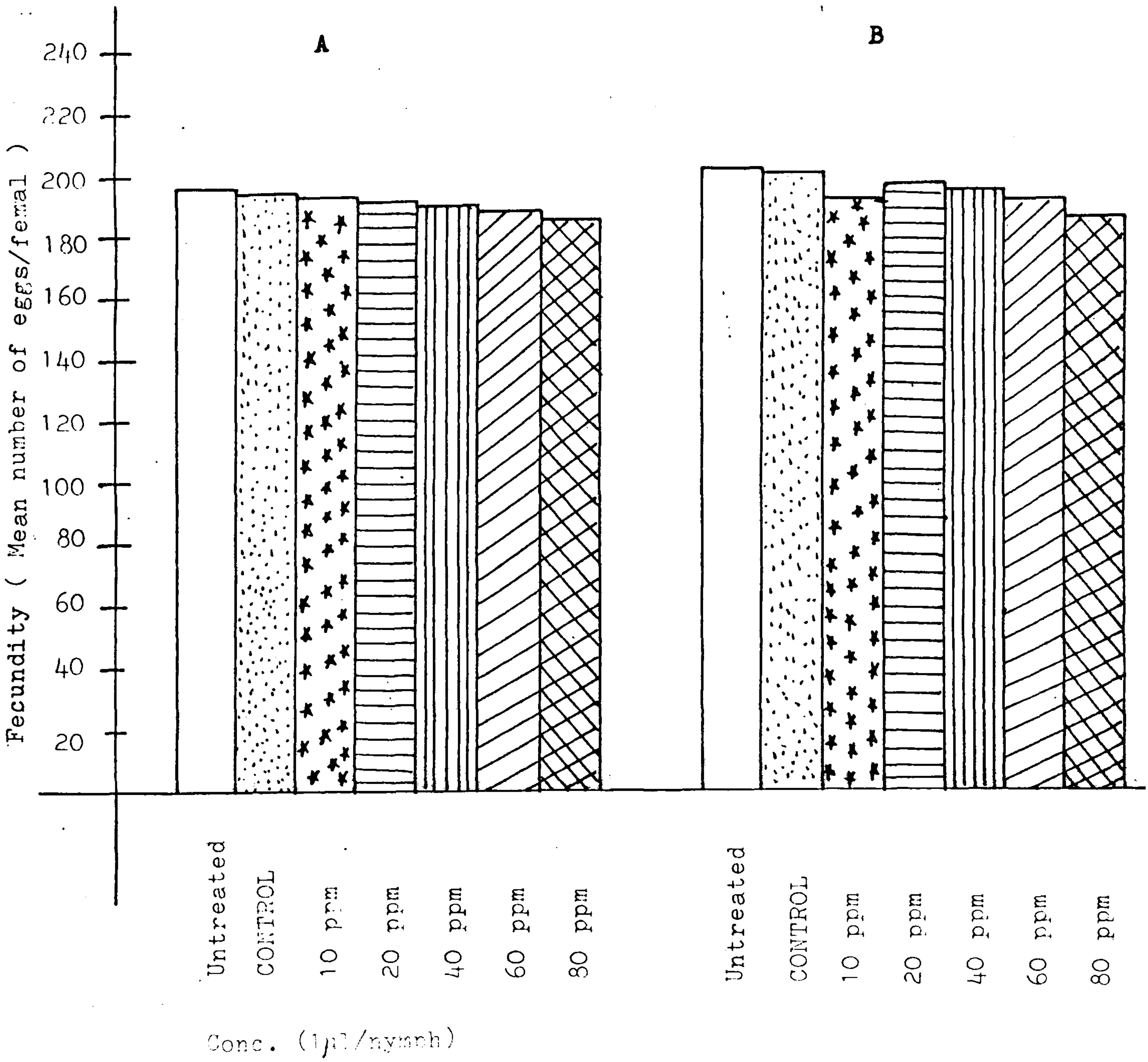

A
B
240
220
200
180
160
140
120
100
80
60
40
20
Fecundity (Mean number of eggs/femal)
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Conc. (1μl/nymph)

Fig. 3: Showing reduction in the egg fertility of female *Dysdercus cingulatus* emerged following the topical application of different concentrations of cythion to the 4th and 5th instar nymphs respectively.

A= 4th instar nymphs.

B= 5th instar nymphs.

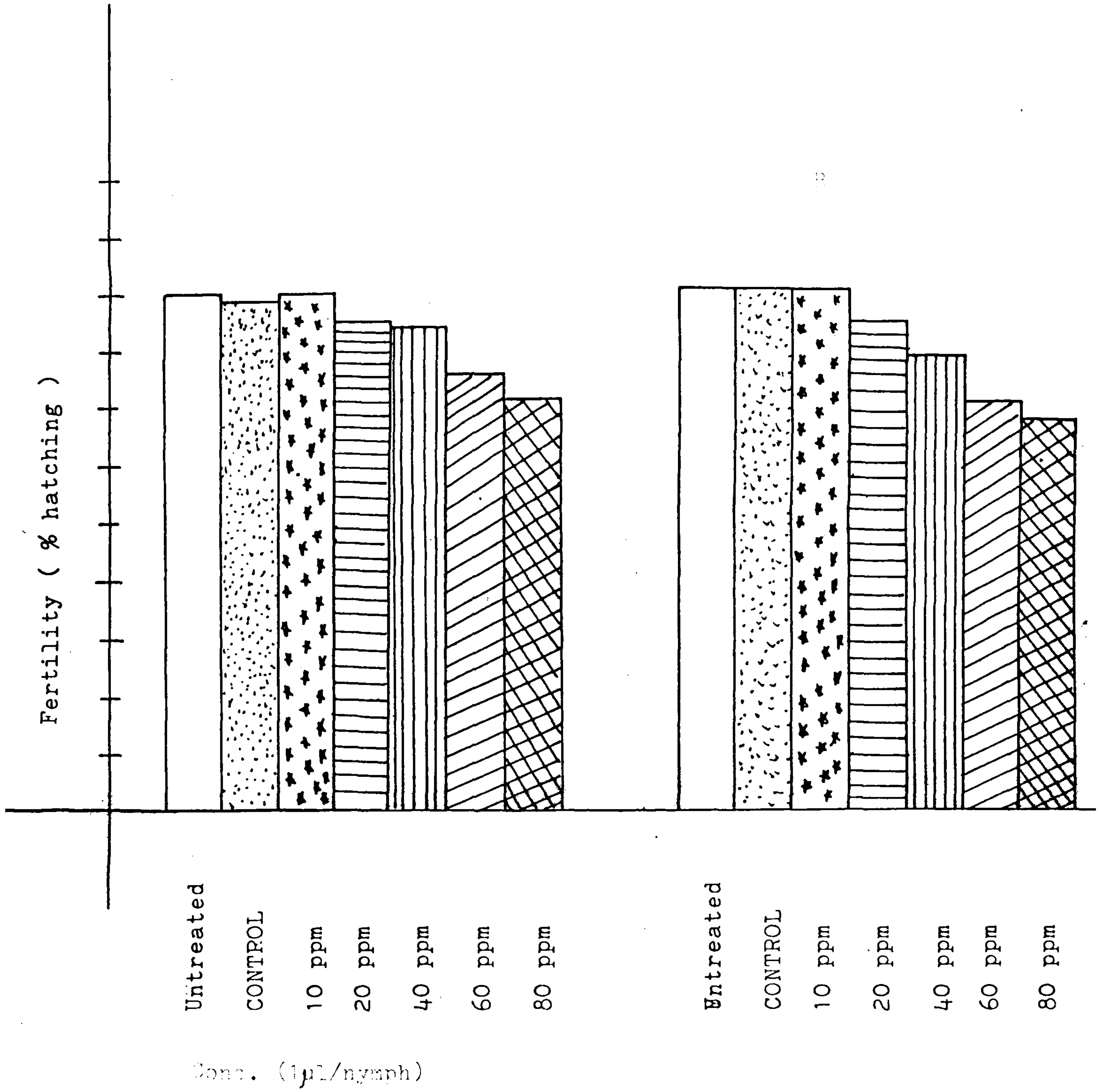

Fertility (% hatching)
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Conc. (1µl/nymph)

Fig. 4: Showing total nymphal mortality up to adult emergence in F_1 generation following the topical application of different concentrations of cythion to the 4th and 5th instar nymphs of <u>Dysdercus cingulatus</u> respectively in F generation.

A= 4th instar nymphs.

B= 5th instar nymphs.

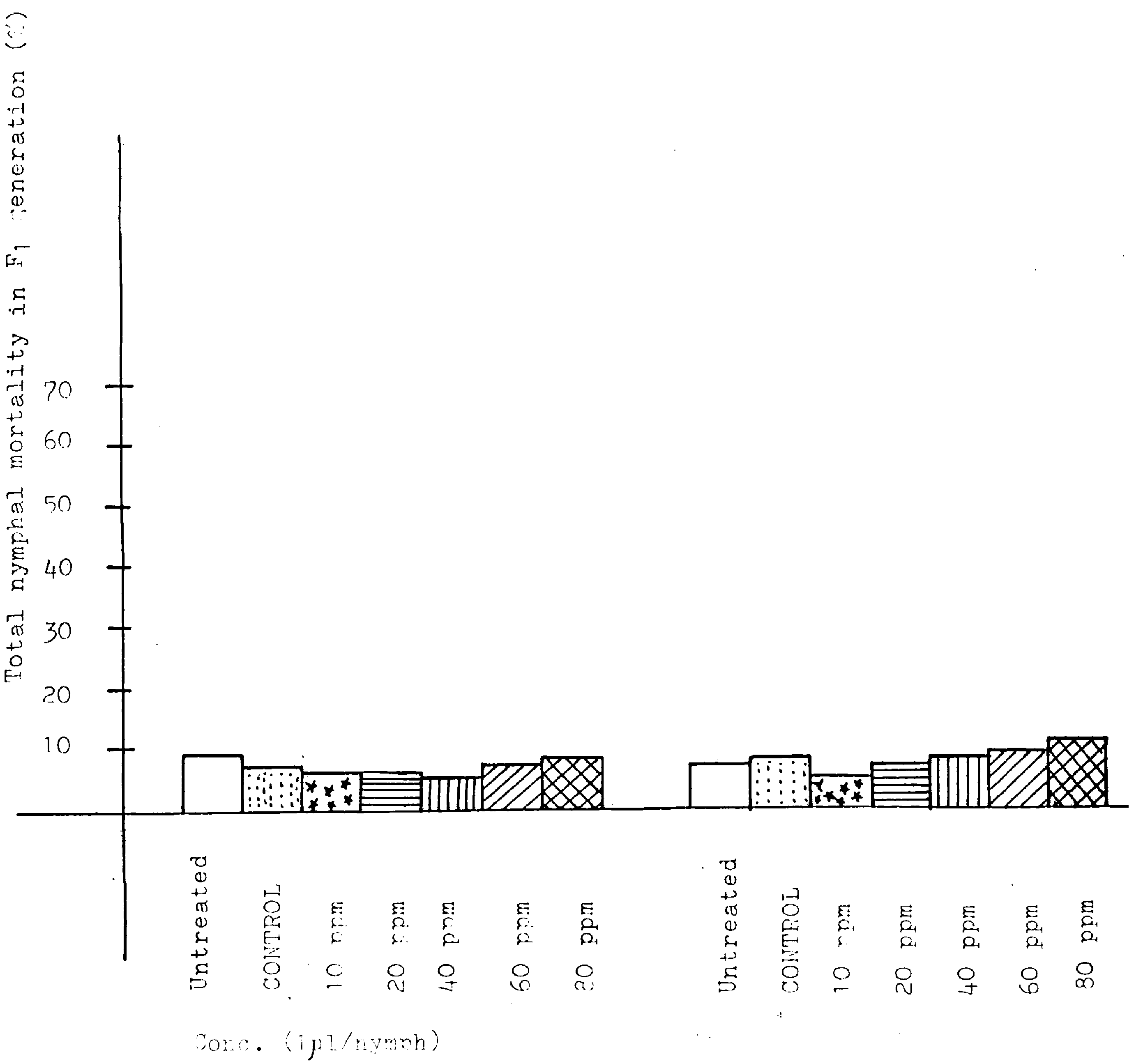

Total nymphal mortality in F1 generation (%)
70
60
50
40
30
20
10
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Conc. (ipl/nymph)

Fig. 5: Showing reduction in the fecundity of female Dysdercus cingulatus (F_1 generation) following the topical application of different concentrations of cythion to the 4th and 5th instar nymphs respectively in F generation.

A= 4th instar nymphs.

B= 5th instar nymphs.

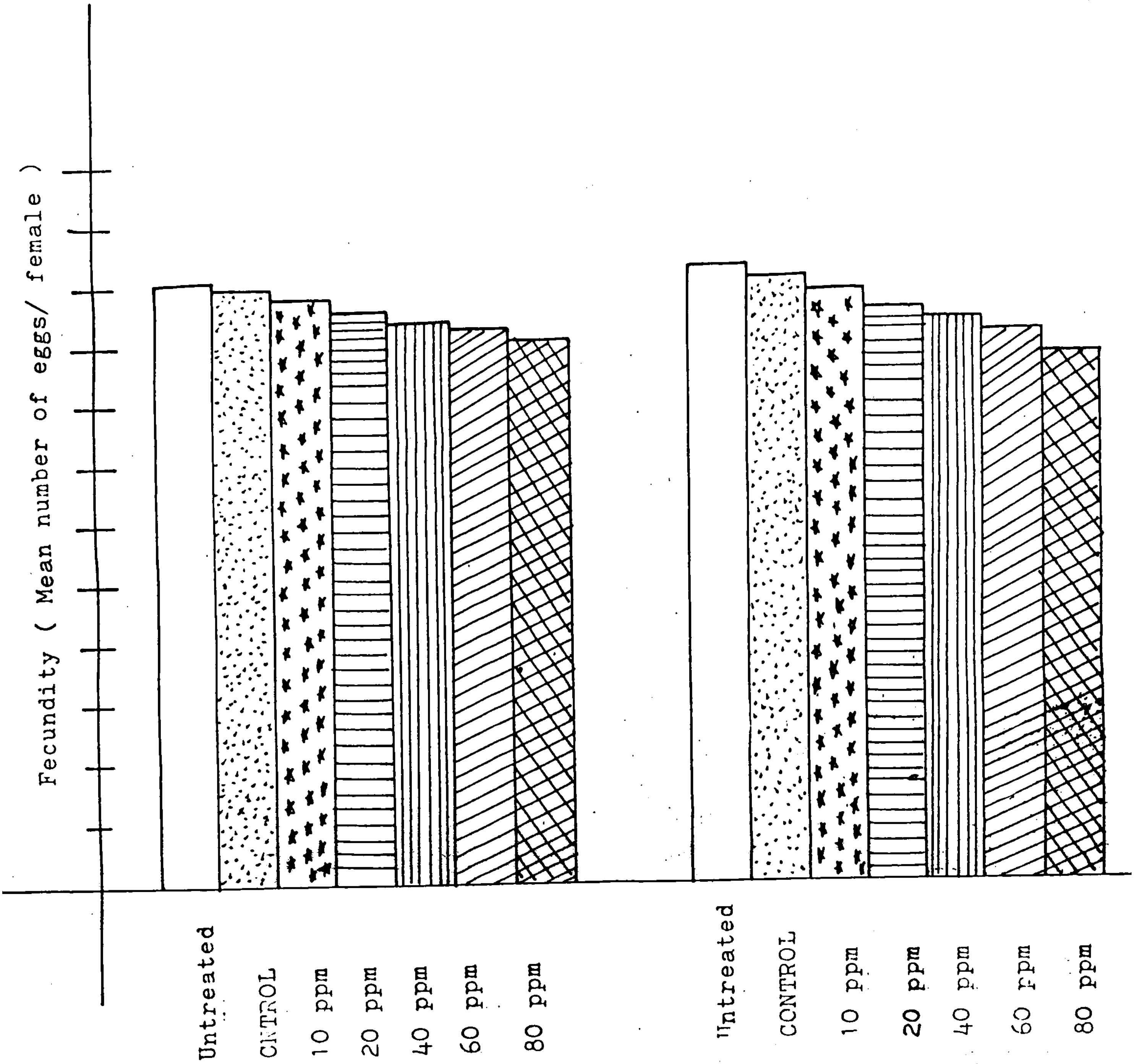

Fecundity (Mean number of eggs/ female)
Untreated
CNTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm

Fig. 6: Showing reduction in the egg fertility of female *Dysdercus cingulatus* (F_1 generation) following the topical application of different concentrations of cythion to the 4th and 5th instar nymphs respectively in F generation.

A= 4th instar nymphs.

B= 5th instar nymphs.

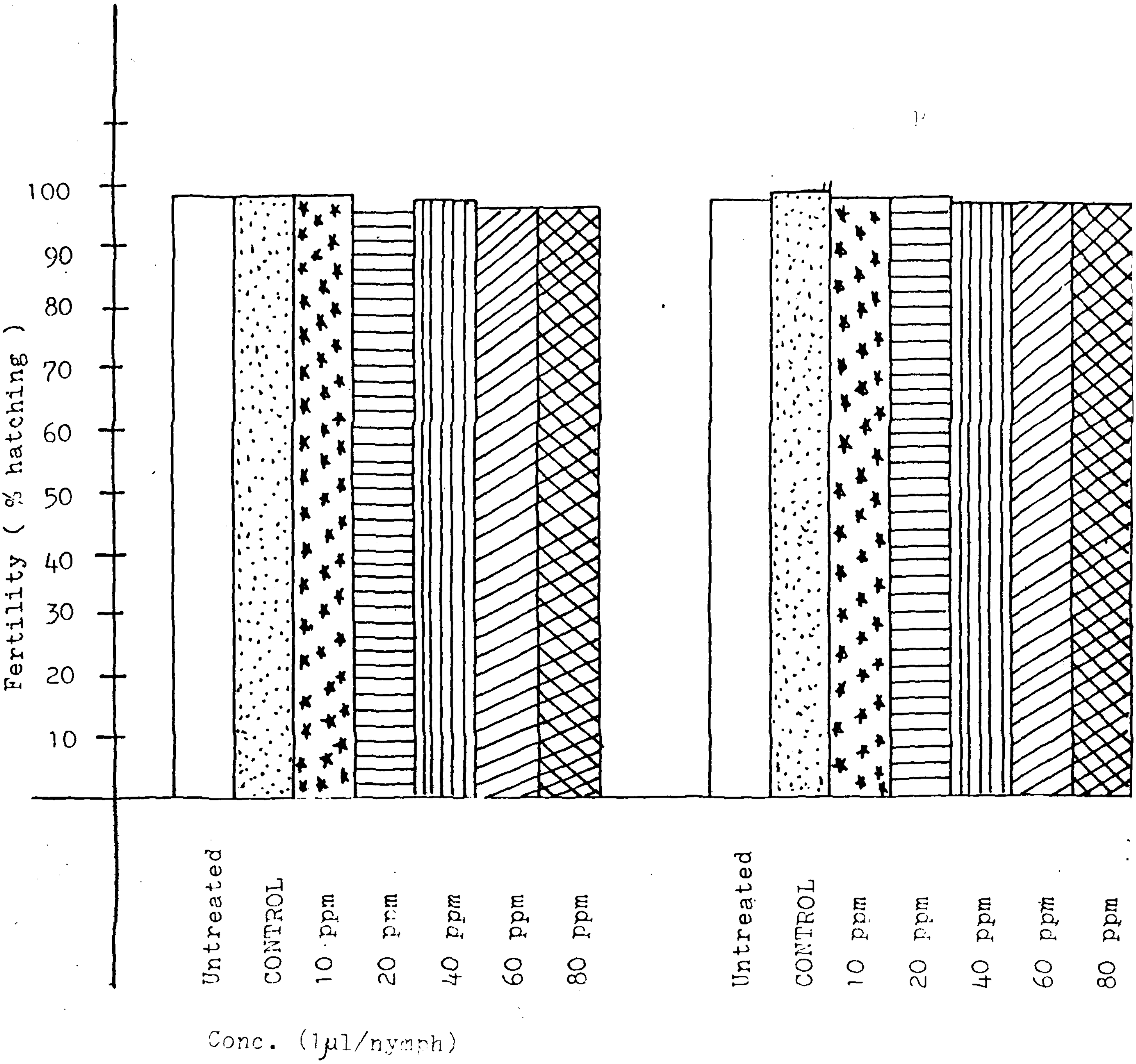

Fertility (% hatching)
100
90
80
70
60
50
40
30
20
10
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Untreated
CONTROL
10 ppm
20 ppm
40 ppm
60 ppm
80 ppm
Conc. (1µl/nymph)

Fig. 7: Showing total larval and pupal mortality up to adult emergence following the topical application of different concentrations of cythion to the 5th and 6th instar larvae of Spodoptera litura respectively.

A = 5th instar larvae.

B = 6th instar larvae.

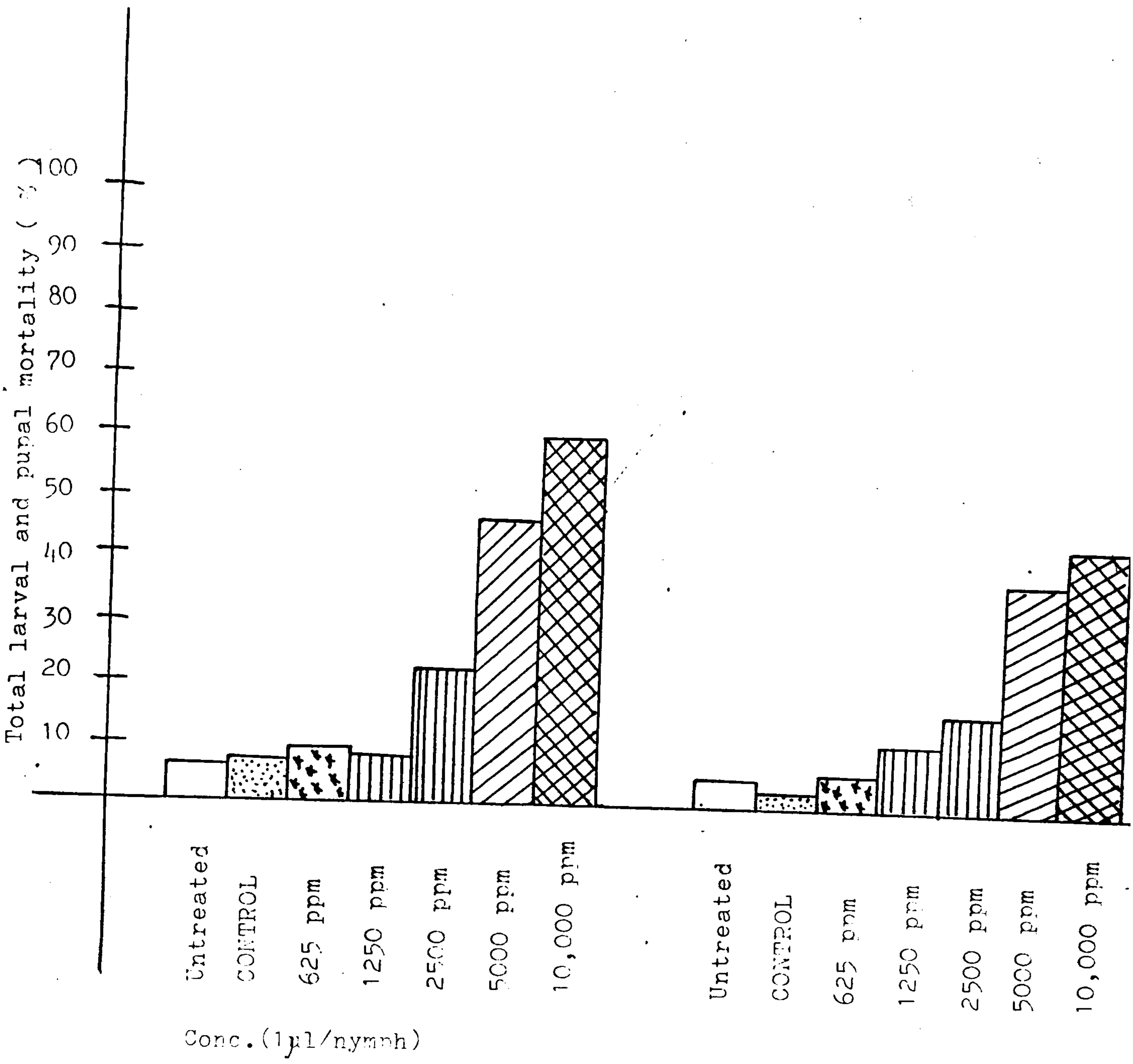

Total larval and pupal mortality (%)
100
90
80
70
60
50
40
30
20
10
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5000 ppm
10,000 ppm
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5000 ppm
10,000 ppm
Conc.(1µl/nymph)

Fig. 8: Showing reduction in the fecundity of the female *Spodoptera litura* emerged following the topical application of different concentration of cythion to the 5th and 6th instar larvae respectively.

A = 5th instar larvae.

B = 6th instar larvae.

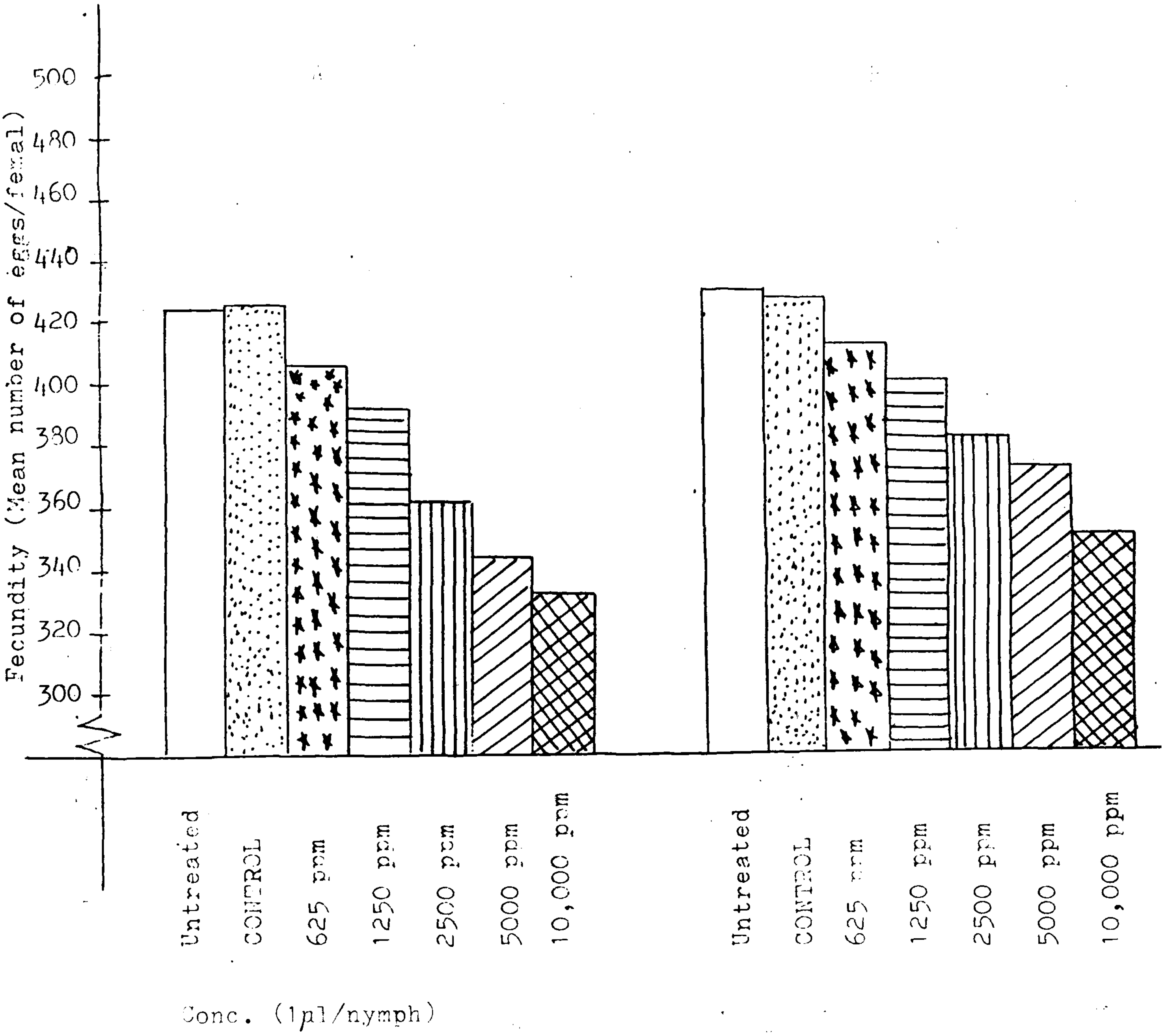
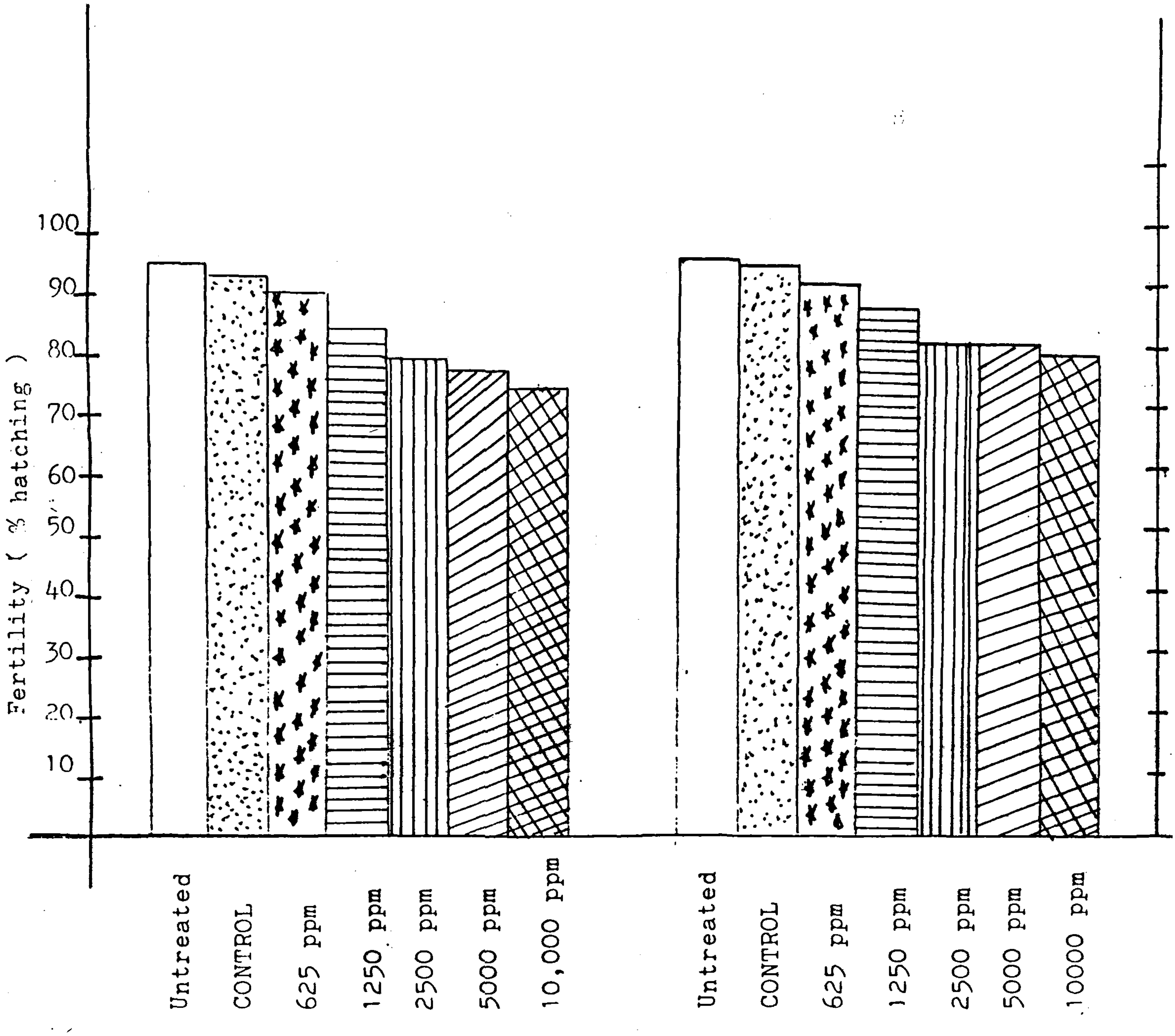

Fecundity (Mean number of eggs/femal)
500
480
460
440
420
400
380
360
340
320
300
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5000 ppm
10,000 ppm
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5000 ppm
10,000 ppm
Conc. (1µl/nymph)

Fig. 9: Showing reduction in the egg fertility of female Spodoptera litura emerged following the topical application of different concentrations of cythion to the 5th and 6th instar larvae respectively.

A = 5th instar larvae.

B = 6th instar larvae.



Conc. (1µl/nymph)

Fig. 10: Showing total larval and pupal mortality up to adult emergence in F1 generation following the topical application of different concentrations of cythion to the 5th and 6th instar larvae of *Spodoptera litura* respectively in F generation.

A = 5th instar larvae.

B = 6th instar larvae.

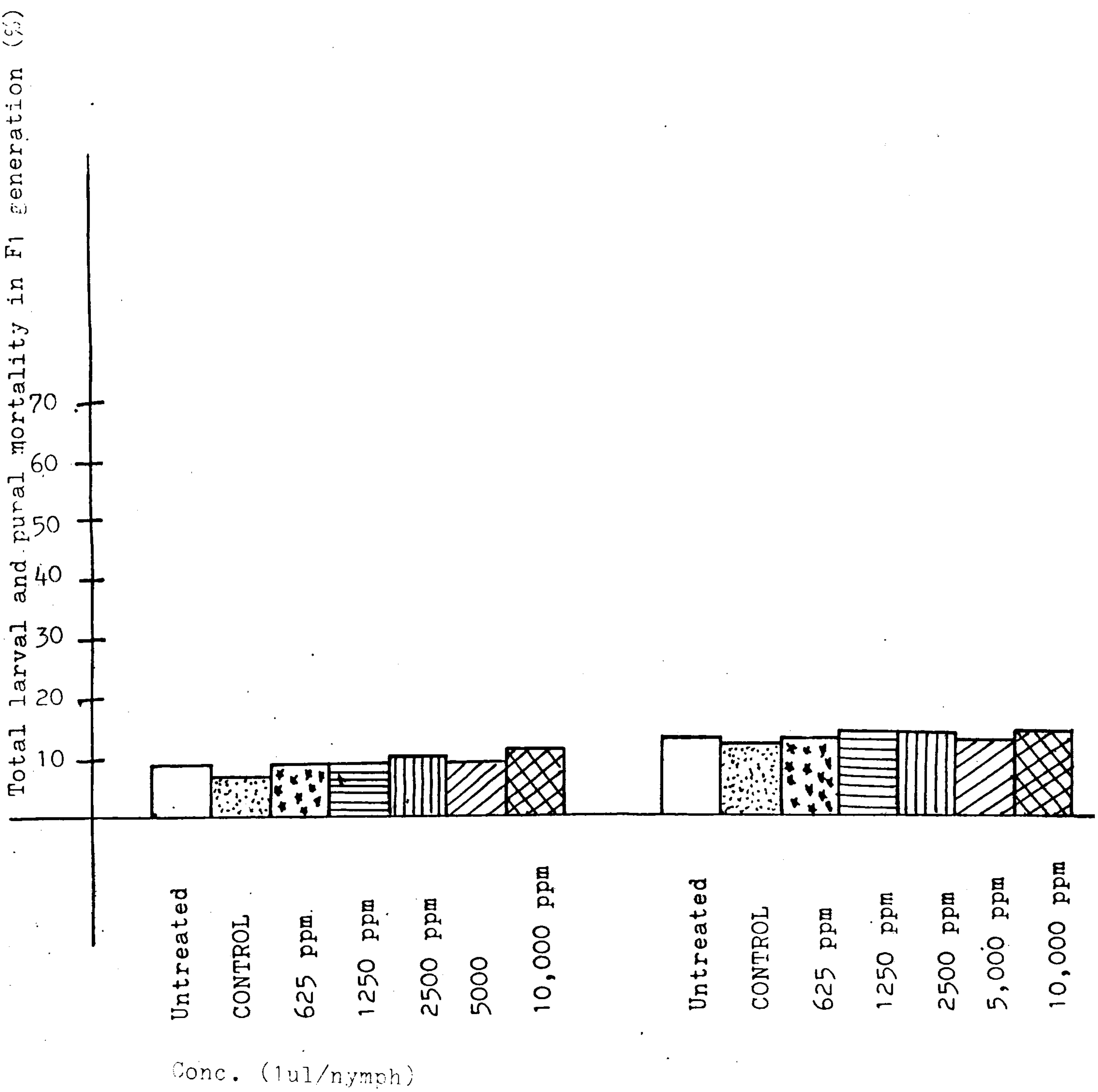

Total larval and pural mortality in F1 generation (%)
70
60
50
40
30
20
10
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5000
10,000 ppm
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5,000 ppm
10,000 ppm
Conc. (1ul/nymph)

Fig. 11: Showing reduction in the fecundity of the female *Spodoptera litura* F_1 generation following the topical application of different concentrations of cythion to the 5th and 6th instar larvae in F generation.

A = 5th instar larvae.

B = 6th instar larvae.

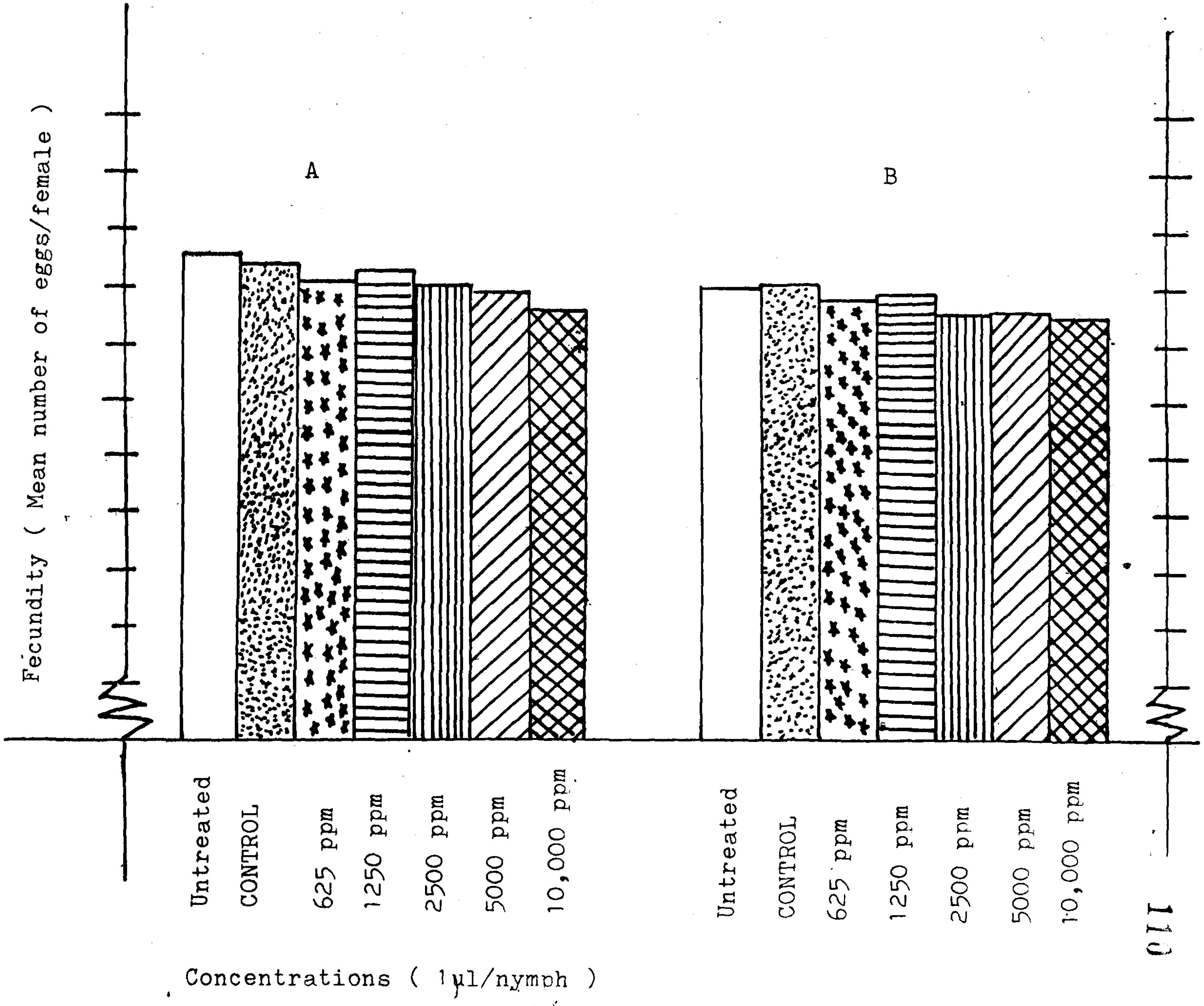
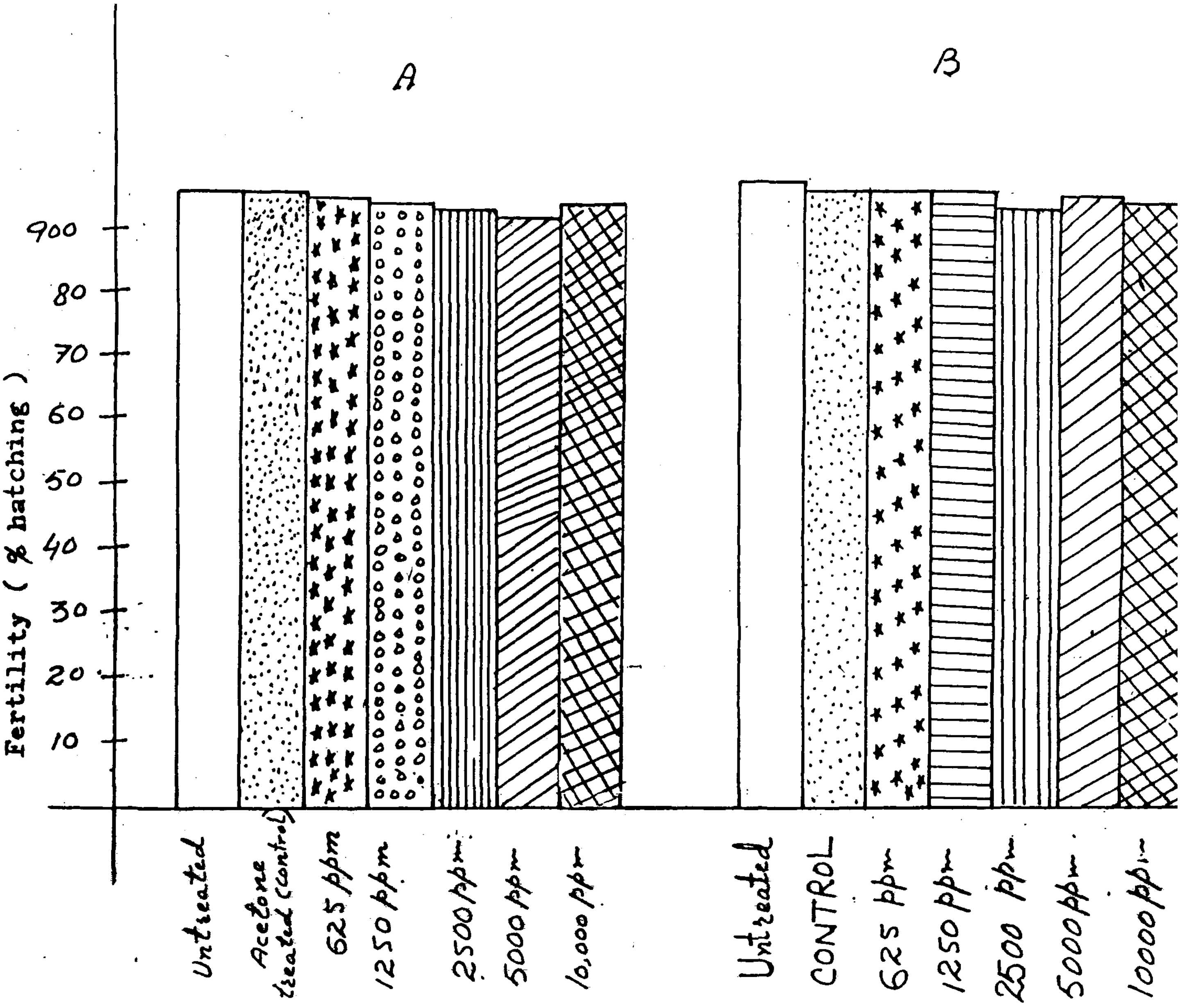

A
B
Fecundity (Mean number of eggs/female)
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5000 ppm
10,000 ppm
Untreated
CONTROL
625 ppm
1250 ppm
2500 ppm
5000 ppm
10,000 ppm
Concentrations (1µl/nymph)

Fig. 12: Showing reduction in the egg fertility of female *Spodoptera litura* F_1 generation following the topical application of different concentrations of cythion to the 5th and 6th instar larvae respectively in F generation.

A = 5th instar larvae.

B = 6th instar larvae.



Conc. (1μl/nymph)

Fig. 13: Showing total nymphal/ larval-pupal mortality up to adult emergence with respect to different types of food provided to nymphs and larvae of Dysdercus cingulatus and Spodoptera litura respectively.

A = Dysdercus cingulatus

B = Spodoptera litura

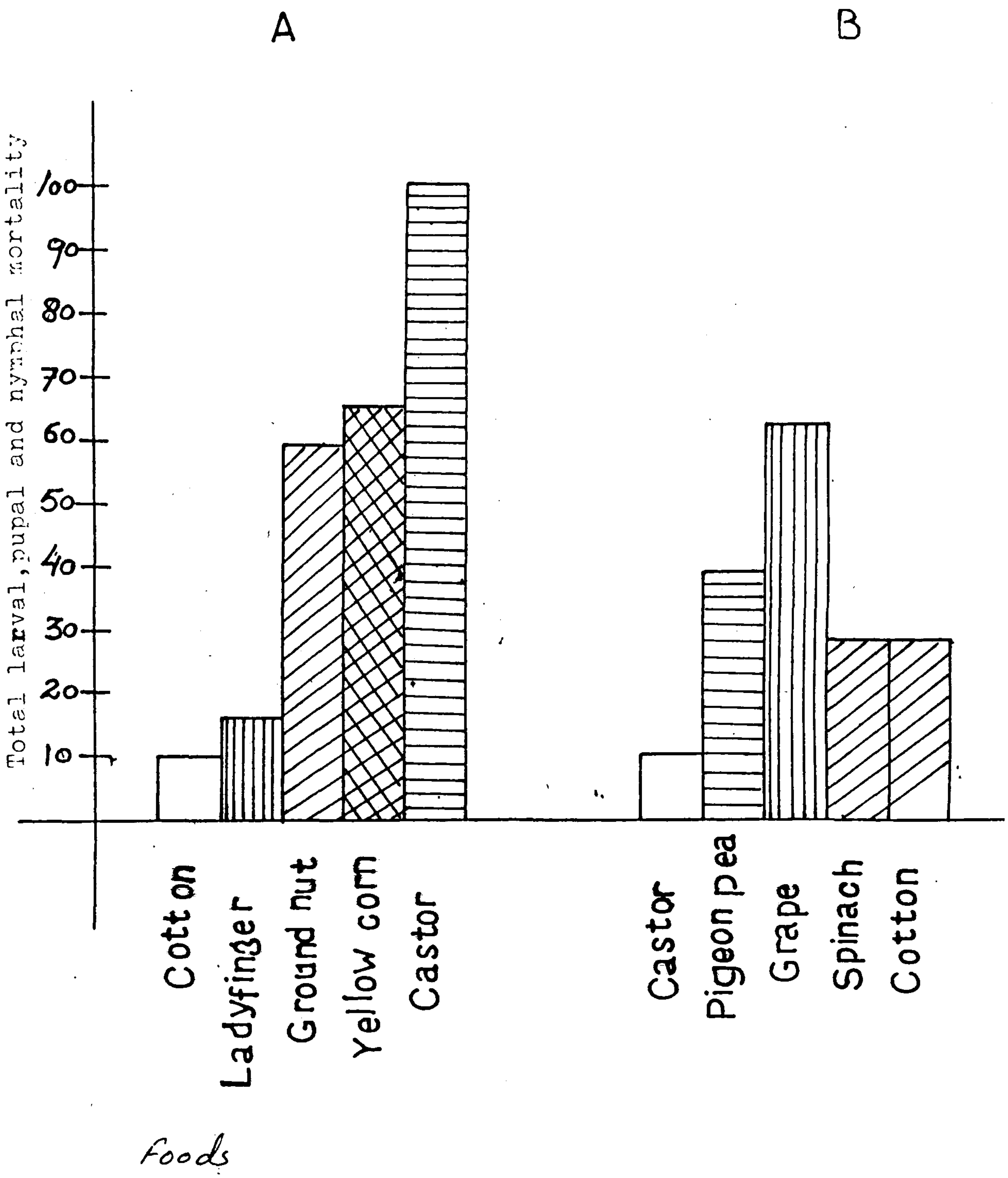

A
B
Total larval, pupal and nymphal mortality
100
90
80
70
60
50
40
30
20
10
Cotton
Ladyfinger
Ground nut
Yellow corn
Castor
Castor
Pigeon pea
Grape
Spinach
Cotton
Foods

Fig.14: Showing reduction in the fecundity of female *Dysdercus cingulatus* and *Spodoptera litura* emerged from nymphs/larvae provided with different types of food.

A = *Dysdercus cingulatus*.

B = *Spodoptera litura*.

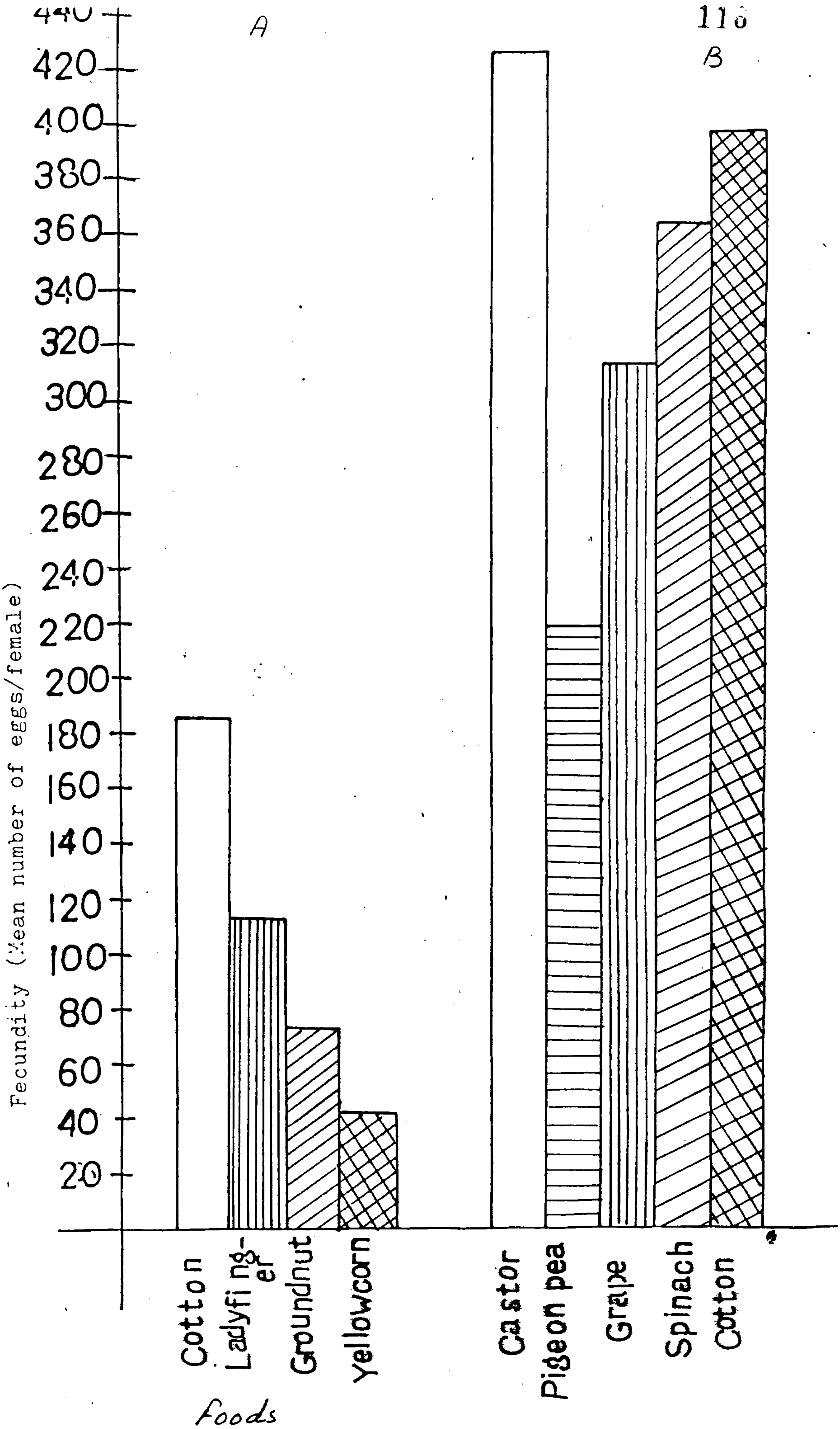
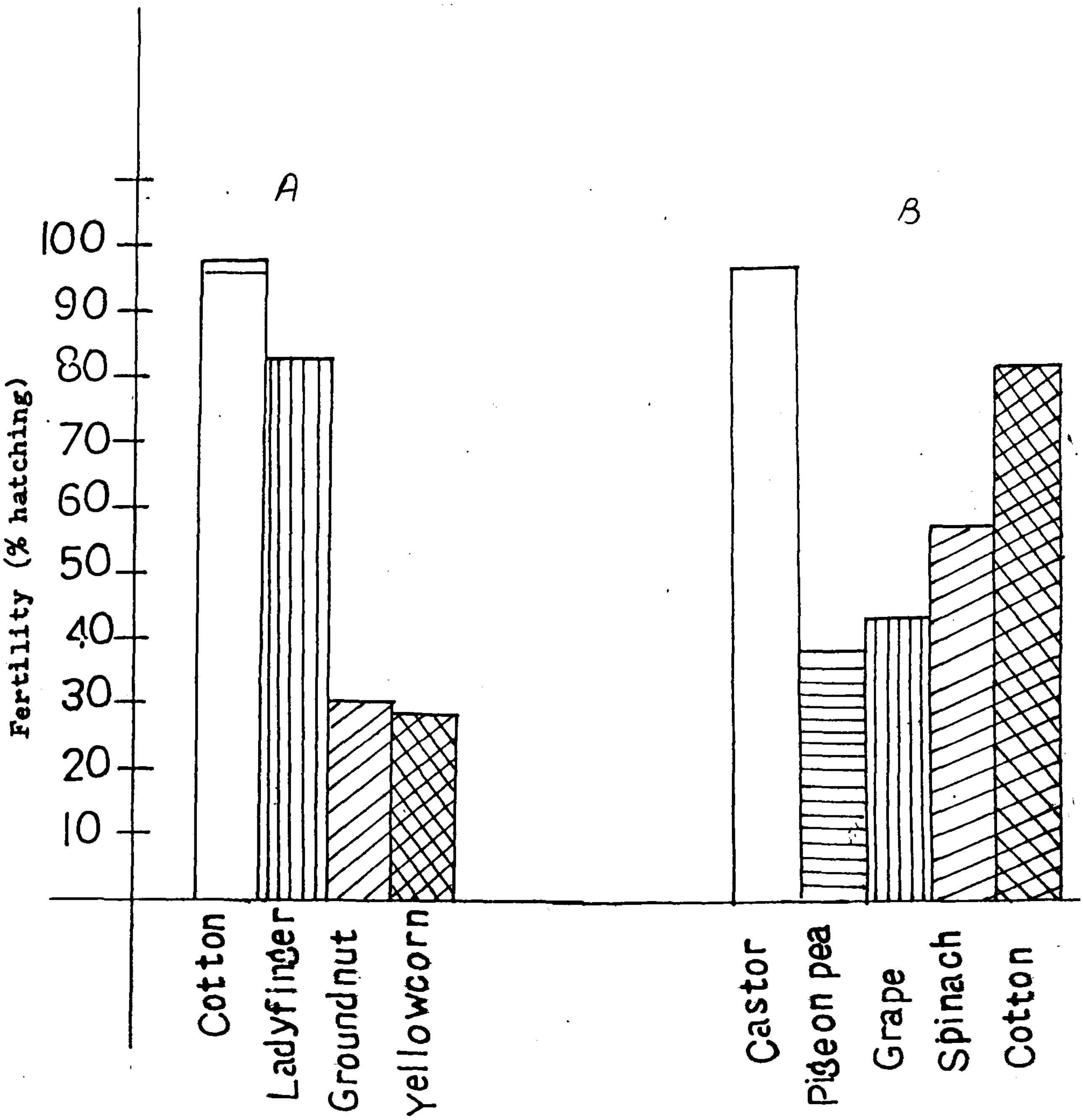

A
B
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
Fecundity (Mean number of eggs/female)
Cotton
Ladyfinger
Groundnut
Yellowcorn
Castor
Pigeon pea
Grape
Spinach
Cotton
Foods

Fig. 15: Showing reduction in the egg fertility of female *Dysdercus cingulatus* and *Spodoptera litura* emerged from nymphs/larvae provided with different types of food.

A = *Dysdercus cingulatus*.

B = *Spodoptera litura*


A
B
Fertility (% hatching)
100
90
80
70
60
50
40
30
20
10
Cotton
Ladyfinger
Groundnut
Yellowcorn
Castor
Pigeon pea
Grape
Spinach
Cotton

FOODS

Fig.16: Showing longevity of nymphs and adults of *Dysdercus cingulatus* with respect to different types of food.

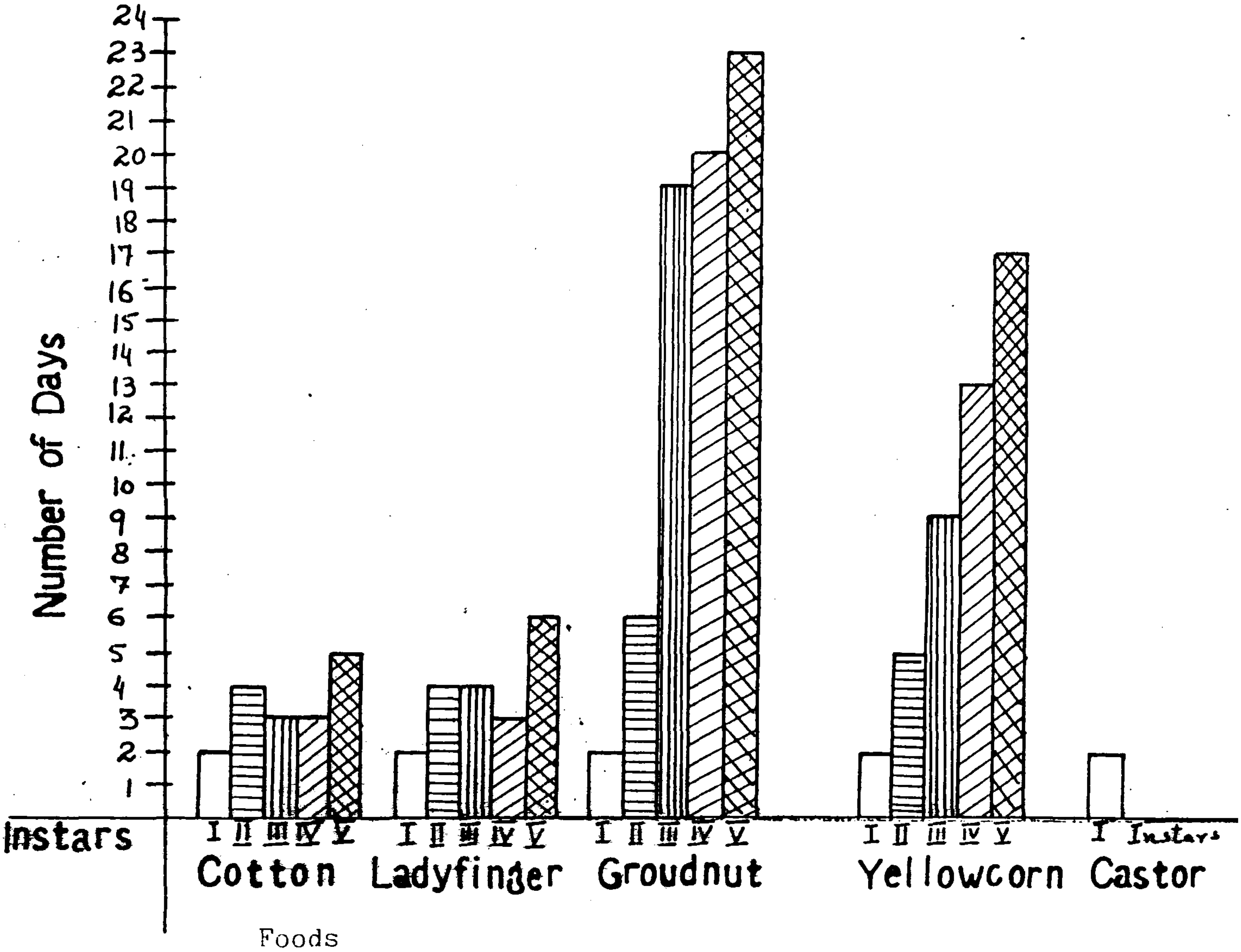
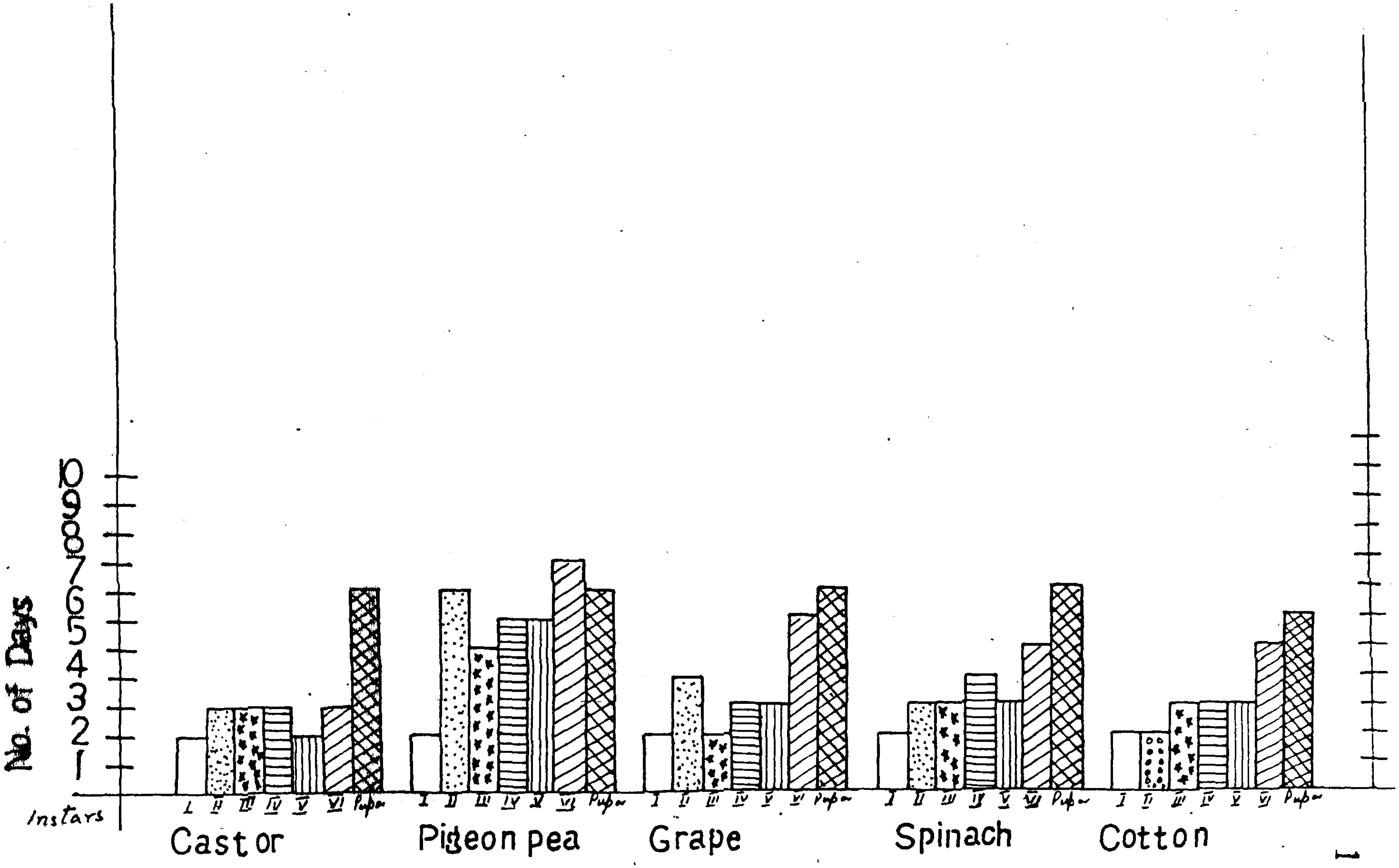

Number of Days
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Instars
I II III IV V
Cotton
I II III IV V
Ladyfinger
I II III IV V
Groudnut
I II III IV V
Yellowcorn
I Instars
Castor
Foods

Fig.17: Showing longevity of larvae,pupae and adults of *Spodoptera litura* with respect to differet types of food.


No. of Days
1
2
3
4
5
6
7
8
9
10
Instars
I II III IV V VI Pupa
Castor
Pigeon pea
Grape
Spinach
Cotton

DISCUSSION

There are different groups of insecticides like chlorinated hydrocarbons, organophosphates, pyrethroids, carbamates etc. besides hormones and pheromones, whose effects on growth and reproduction have been studied in several species of insects. Till only a few years ago, two great groups of compounds dominated all the rest: the axonic agents, of which the most important representatives were a chlorinated hydrocarbons and the anticholinesterases. Because of the persistant nature of most chlorinated hydrocarbons, they have undergone a rather dramatic replacement from use in recent years, so that the market place is now dominated by the anticholinesterases, that is to say the organophosphate and carbamate compounds. The effects of these insecticides have been worked out on a number of species of pest insects. The results reveal that there is a wide range of variation of response and susceptibility with respect to different insect species against an organophosphate insecticide. Thus it becomes inevitable to find out the most effective insecticide against particular species of insect pest. Gargav and Patel (1976) studied several organophosphate insecticides and found out that fenitrothion, diethchin and monocrotophose gave 100%, 100% and 94.5%

mortality respectively. They also reported that DDT + BHC and endrin which belong to chlorinated hydrocarbon group gave 30% and 0.5% mortality when tested against *Nymphula depunctalis*. In the same year Page and Lyon, showed that chlorpyrifos and resmethrin were both over 240 times more toxic than DDT and phoxin and diazinon was 130 times more toxic than DDT to the larvae of *Chrysomela scripta*. Goodyer (1985) on the basis of their studies of topical application of 14 insecticides on the 4th instar caterpillars of *Mythimna convecta* and *Persetania ewingii* reported that Permethrin, methomyl, fenvalerate and chlorpyrifos were more toxic to the caterpillars than DDT. Earlier, Chiba et. al. (1978) observed that dimethoate was the best of 7 insecticides for control of *Lygus lineolaris*. The 50 percent mortality (LC-50 value) were observed with 13.2, 5.3, 3.9, 1.2, 0.73, 0.11 and 0.05 g (a.i)/1 insect for DDT, Phasolan, endosulfan, phasmet, teterachlorrinphos, fenitrothion and dimethoate respectively.

In the present investigation application of 10 ppm, 20 ppm 40 ppm, 60 ppm and 80 ppm per 4th & 5th instar nymph on *Dysdercus cingulatus* and 625 ppm, 1250 ppm, 2500 ppm, 5000 ppm and 10,000 ppm on 5th and 6th instar larvae of *Spodoptera litura* by topical method caused nymphal and larval mortality. The rate of mortality increased with the successive stronger concentrations. Total nymphal and larval mortality was comparatively higher when the insecticide was applied on the less advanced (4th instar nymph and 5th instar larvae) than the more advanced ones (5th instar nymph and 6th instar larvae). Topical application of strongest concentration (80 ppm) of cythion on 4th instar nymphs of D. cingulatus caused the total nymphal mortality by 57% whereas, on treating the 5th instar nymphs with the same concentration the nymphal mortality was 40%. In the same way the topical application of the strongest concentration (10,000 ppm) of cythion to the 5th instar larvae of Spodoptera litura resulted in the total (larval + pupal) mortality by 60% whereas, on treating the 6th instar larvae with the same concentration the respective mortality was 43%. Whereas according to Kumar et. al. (1986) Baygon (carbamate), at the concentration of 0.06% gave 100% mortality against Dysdercus koenigii. Further Nielsen (1983) studied the effect of topical application of Bendiocarb and acephate to the adults of Otiorhynchus gulcatus and reported that bendiocarb caused 90% mortality with 0.1% whereas acephate was non-toxic but ingestion of foliage with a 0.1% concentration caused 90% mortality. Similarly, Hussain and Qayyum in 1975 observed 0.1% concentration of malathion, diazinon and nogos caused 73.80%, 71.77% and 59.80% mortality respectively. The same insecticide at 0.05% gave 67.91%, 61.93% and 48.50% mortality respectively when applied to the larvae of T. granarium. Further, Gargav and Patel (1976) observed that fenitrothion, diethchinalphion, carbaryl and monocrotophos gave 100%, 100%, 97.5% and 94.5% mortality respectively. Birlane gave 56.9% mortality against the Nymphula depunctalis. As reported by Shrivastava and Gopal in 1985 the toxicity of seven organophosphorous insecticides against five stored grain pests. He observed the LC-50 values of baythion, trinfos, bromophose, fenitrothion, Iodofenophos, malathion and primiphos-methyl against all five pests. He suggested that baythion and etrimfos were most toxic. The respective LC-99 values were 25.30 ppm and 10.33 ppm against Trogoderma granarium and Callasorbruchus maculatus. As reported by Werner et. al. (1984) the toxicity of nine insecticides by topical application, the decreasing order of toxicity of LD-50 was: permethrin, chlorpyrifos, fenvalerate, fexitrothion, pirimiphos-ethyl-primephos-methyl etrimphos, phosmet and carbaryl. Femtrothion at 2% provided the best remidial control. Further, Emori and Sugiyama (1983) studied that the oral toxicity of dimethoate to adults of Psacothea hilaris reached the value of LD-50 at 0.88 ug/g and was 250 times higher than that to the larvae (LD-50 at 220 ug/g). Johansen and Davis (19) studied that methomyl, malathion, diazinon, carbaryl, methoxychlor, DDT, chlordane, taxophene and trichlorfan gave 50 percent mortality and out of these insecticides methomyl was determined to have the higher toxicity at 0.9 ug/g body weight when applied topically to the warkers of Vespula pensyvanica. According to Klein et. al.

(1982) studied effect of several insecticides on the larvae of *Spodoptera litura* and suggested that the doses needed for 90% mortality (LD-90) of the 2nd instar larvae were 8.5, 35, 280, 1300 and 340 g a.i/1000 m^2 for chlorpyrifos, methomyl, profenofos, methyl parathion and ethyl parathion respectively; monocrotophos was inactive against 2nd instar larvae even at relatively high doses.

Both fecundity and fertility of *D. cingulatus* and *Spodoptera litura* were adversely affected by the cythion. Although, reduction in the fecundity of females was concentrations based, the fertility of eggs was affected by the stronger concentrations only. Similarly, Shukla and Pandey (1979) studied that thiourea inhibited the egg deposition in *Callosobruchus chinensis* and the number of eggs oviposited decreased with the increase in the concentration of compounds. The effect on both fecundity and fertility was more prominent when the application was made on the more advanced stage than on that of the less advanced stage. Topical application of 80 ppm cythion/nymph to the 4th instar nymphs caused reduction in the fecundity of the emerged females by 7.59%. Similarly reduction in the fertility was 18.88 % with respect to this concentration on 4th instar nymphs. The similar application (80 ppm/nymph) on the 5th instar nymphs caused fall in the fecundity by 11.47% and that in the fertility by 22.08%.

Further, the topical application of 10,000 ppm cythion/larva to the 5th instar caterpillars caused reduction in the fecundity of the emerged females by 22.54%. Besides there was reduction in the fertility of the eggs laid by the affected females. By similar application on the 6th instar larvae the fall in the fecundity and fertility was 17.76% and 14.97% respectively which were significant. However, Bariola and Lindquist found that monocrotophos at 0.8 mg/dish caused 23% reduction in eggs oviposited by the surviving females during the 10-14 day period and Dicrotophos at 0.9 mg/dish caused 40% reduction in fecundity during the 10-14 day period to the Anthonomus grandis. Fenvalerate methamidophos and carbaryl also inhibit females fecundity of the dimondback moth, Plutella xytoslella (Kumar and Chapman, 1985). Topical application of dieldrin to the 5th instar nymphs of Dysdercus faciatus at 0.2-0.6 µg/individual increased egg production but 0.8-6.0 µg/individual decreased egg production and 0.6-6.0 µg/individual decreased fertility (Hodjat, 1971). Further, he also observed that 0.2 µg/individual reduced egg production when applied to 4th instar nymphs but had no effect on 5th instar or adult. 2-4 µg of dieldrin when applied to the adults caused reduction in egg production. Parker, et. al. (1977) observed that when malathion was applied topically to 24-48 hrs old Menochilus sexmacutalus adults, virgin female laid fewer eggs than mated females. He also reported that the sublethal doses of malathion had the greatest effect on fecundity. Shukla and Singh (1983) studied that calchicine induced 100% sterility in *Chrysoma megacephela* when exposed to 0.18% for 120 minutes.

There was no significant effect of even the strongest concentration of cythion in the F_1 generation of either *D. cingulatus* or *S. litura*. Adult emergence as well as fecundity and fertility of the treated individuals were similar to those of the control.

On the basis of present data on *D. cingulatus* and *S. litura* it is concluded that topical application of cythion in its sublethal concentration causes not only heavy mortality but also reduction in the fecundity and fertility, thus bringing out check on their population. Therefore, cythion an organophosphate insecticide can be recommended for the control of these species of insects.

The effect of various types of food has been observed on growth and reproduction of *Dysdercus cingulatus* and *Spodoptera litura*. Five different types of food viz, seeds of lady finger, groundnut, yellow corn, castor and cotton were given to the newly hatched nymphs. The development of *D. cingulatus* was greatly influenced by the food. When the nymphs were offered castor seeds none of the nymphs crossed the 4th instar and 100% mortality occurred upto 4th instar.

Mortalities were 65% and 59% with respect to yellow corn and ground nut as compared to only 09 % in control (on cotton seeds). Similarly, when five different types of food viz., leaves of pigeon pea, grapes, spinach, cotton and castar were given to the newly hatched larvae of Spodoptera litura. The highest survival percentage (90%) was obtained on castar leaves and the lowest survival was on pigeon pea leaves (38%). Similar observations were made by Dube and Chand (1978) on the development of Plutella xylostella on 5 food plants. The duration of larval and pupal periods as well as percentage of individual reaching the adult stage varied with food upon which the insect was reared. Radish and knol knol proved to be unfavourable foods as compared to cauliflower, cabbage and mustard. On the basis of above observation the seeds of different crops may be arranged in descending order of their nutritive value for D. cingulatus in relation to the survival of the nymphs; cotton yellow corn ground nut lady finger castar. Similarly, the leaves for S. litura may also be arranged in descending order in relation to the survival of the larvae, castar cotton spinach grape pigeon pea.

It is also apparent from the Table 11 and 23 that the nymphal and larval duration is affected by different foods. It may be noted that the nymphs of D. cingulatus when reared on ground nut take 70 days to attain the adult stage as compared to 17 days on cotton seeds. The nymphs of 3rd, 4th and 5th instar reared on ground nut and yellow corn took 19 and 9 days, 20 and 13 days, 23 and 17 days respectively, as compared to 3 days, 3 days and 5 days, respectively on cotton to reach adult stage. In case of *Spodoptera litura* larvae reared on pigeon pea took 41 days as compared to 23 days on castar to attain adult stage. The larval duration of 6th instar increased by 5 days, 3 days, 2 days and 2 days on pigeon pea, grape, spinach and cotton leaves respectively as compared to castar. The larval duration of 2nd instar increased by 4 days when the nymphs were fed on pigeon pea. Similar observations have been made by Ewete and Osisanxa (1986) on the effect of various diets(seeds) on development,longevity and fecundity of the cotton seeds bug *Oxyceraneus gossypinus* and found out that the development longevity of bugs were 15.5, 14.7, 15.8, 18.1 days on the seeds of okra, kenaf, roselle and cotton respectively. Mated females reared on okra seeds laid significantly higher number of eggs per day (15.05 $\pm$ 0.87 eggs) as those which were reared on seeds of kenaf (12.9 $\pm$ 1.01 eggs) and roselle (10.9 $\pm$ 1.18 eggs). Further, Stewart and Baker (1970) observed that larval period of *M. sexta* was 2 days longer when reared on tobacco leaves than those which were reared on the artificial diet. Weight of larvae at the end of 5th stadium and resulting pupae were approximately the same on both diets. According to Hassanein et. al. (1973) feeding of cotton leaves prolonged the larval period in *Spodoptera xiqua* whereas, feeding of cotton leaves did not effect the larval period in *Spodoptera litura*. Feeding of potato leaves shortened the larval period of *S. exiqua*. Feeding on different crops did not affect the pupal period in the male, but feeding on cow-pea (*Vigna sinensis*) leaves shortened the female pupal period. Further, Baker and Miller (1974) studied the development of all stages of *Spodoptera litoralis* and reported that development was faster on Lucerne (*Medicago sativa*) than that on 2 cultivars of chrysanthemum, Taffeta and Fred Shoesmith. Smilarly, Zaagou et. al. (1974) studied that when larvae of *Agrotis ipsilon* were reared on bersum, the larval duration shortened by 11.6 days than those reared on chick pea leaves (32.8 days). All Ist instar larvae reared on maize leaves died after 8 days while 20% of those reared from the 4th instar on such leaves survived and pupated. Ist and 4th instar larvae reared on fenugreek died after 4-7 days. The larval durations were clearly correlated with the percentage of water content and crude protein. Weight of one day old pupae were highly affected by larval food plant. Weight declining in the order castar oil > leucerene > cotton > chick pea > egyptian > lupin. Adult longevity was also affected by the larval food. Further, Abdel-Fattah, et. al. (1978) observed that lettuce, sweet potato, castar oil, cow pea and cabbage proved to be the most favourable larval food for <u>Spodoptera litura</u> due to their high content of total carbohydrate, total nitrogen and essential growth elements. On these host plants the shortest larval and pupal periods, the heaviest pupae, the longest adult life span and the highest number of eggs were obtained. Contrary to the preceeding were kidney bean, berseems, broad bean, tomato, potato squash and taso.

It was also recorded that nymphal, larval, pupal and adult weight was affected by different foods as well as with respect to the duration of the nymphal/larval instars. The nymphs of <u>D. cingulatus</u> when reared on ground nut took more time as compared to other diets and grew very little. The 3rd, 4th, 5th instar nymphs and adults showed a significant reduction in weight. The weight of 3rd instar nymphs reared upon ground nut was 2.58 mg as compared to 5.13 mg in control (cotton seeds). The weight of 4th instar and 5th instar nymphs and adults was 8.58 mg, 21.57 mg and 32.35 mg as compared to control (cotton seed) 15.39 mg, 48 mg and 61 mg respectively. The 3rd, 4th, 5th instar nymphs and adult also showed marked reduction in weight when offered yellow corn seeds. The weight of 3rd, 4th, 5th instar nymphs and adult on yellow corn seeds were 3.10 mg, 10.27 mg, 24.4 mg and 38.27 mg as compared to control 5.13 mg, 15.39 mg, 48 mg and 61 mg respectively. The nymphs when offered lady finger seeds showed no marked reduction in weight as compared to control. The Ist and

2nd instar nymphs showed no marked reduction on any food. In this way when the larvae of Spodoptera litura were reared on different foods they also showed variation in weight. The weight of Ist instar larvae remained unaffected on all foods whereas the weight of 2nd, 3rd, 4th, 5th, 6th instar larvae, pupae and adults reduced by 10.2, 17.4, 60.0, 121, 447 mg, 213 mg and 90 mg respectively when reared on pigeon pea leaves, Similarly, when the larvae fed on leaves of grape, the weights of 2nd, 3rd, 4th, 5th and 6th instar, pupae and adult reduced by 8.2 mg, 19 mg, 32 mg, 98 mg and 322 mg, 203 mg and 62 mg respectively. When offered leaves of spinach the weight of 2nd, 3rd, 4th, 5th, 6th instar larvae, pupae and adult reduced by 4 mg, 10 mg, 22 mg, 72 mg, 145 mg, 132 mg and 44 mg respectively. The reduction in weights of larvae when fed on cotton leaves of 5th, 6th, instar, pupae and adult were by 17 mg, 53 mg, 149 mg and 53 mg respectively. The weights of 2nd, 3rd and 4th instar larvae remained unaffected. Similar observations were made by Vaish and Agrawal in 1978 that the larval weight, larval duration, growth rate, pupal period, pupal weight and percentage of adult emergence of Spodoptera litura were found to be dependent on the host plant and suggested that sunflower (Helianthus annus) was the best preferred food, followed by cowpea radish green gram rose leaf. Pigeon pea leaves were not preferred. Further, Senapati et. al. (1979) observed that the best growth and shortest duration of development were obtained on okra fruit as larval foood of Earias vitella. The larvae reared on cotton bolls were 5.006 and 1.957 times heavier and the pupae were 2.104 and 1.275 times longer than the larvae and pupae reared on cotton shoot. The growth of larvae and pupae were poorest on cotton shoot and duration of larval period was longest. The larval development on okra fruit was 4.720 times greater than the larval development on okra shoots.

Both fecundity and fertility of Dysdercus cingulatus and Spodoptera litura were adversely affected by different type of food. When the nymphs of D. cingulatus were fed on seeds of yellow corn, the number of eggs laid by the female reduced by 77.3% as compared to the control. The fertility of these females also reduced significantly (68.7%). When the nymphs were offered ground nut the fecundity of the emerged females reduced by 60.9% whereas the fertility of such females reduced by 66.72% as compared to control. Similarly the reduction in fecundity and fertility were 39.46% and 15.13% respectively when the nymphs were fed on seeds of lady finger. On the other hand when the larvae of Spodoptera litura fed on different types of leaves the fecundity and fertility was also affected by the type of leaves. The fecundity was greatly affected when the larvae were fed on pigeon pea. The number of eggs laid by the females emerged from such larvae reduced by 48.6% as compared to control (fed on leaves of castar). Similarly, the fertility also reduced significantly (57.66%). The caterpillars when offered leaves of grape, emerging females showed 26.53% reduction in fecundity and 53.2% reduction in fertility as compared to control. The reduction in the fecundity and fertility of the females which emerged from the larvae fed on leaves of spinach were 14.55% and 38.87% respectively. When the larvae were reared on cotton leaves number of eggs laid by such females reduced by 6.57% and fertility by 14.86%. From the above data it is clear that the dietary variation of D. cingulatus had greater influence on fecundity as compared to fertility. On the other hand dietary variation of Spodoptera litura larvae had greater influence on fertility than that on the fecundity. Similar observation have been made by many authors, Ali, et.al. (1973) observed the influence of natural food on the development and reproductive rate of Lasioderma serricorns. He found that fecundity was significantly greater in females reared on cotton seeds (26.4% protein) than in those reared on bean pods (29.39% protein). Further, Leather (1985) studied that when the adult females of the pine beauty moth Ponolis flammea fed on a saturated honey solution laid more eggs than those individual given water only or not fed at all. Similarly, Hamalainen and Markhula (1973) studied that 3 successive generations of Coccinella septumpunctata laid an average of 1325, 1217, 1882 eggs when fed on Asyrthosiphon pisum which was the best food. Females fed on Macrosiphon rosae began to lay eggs earlier than those fed on Myzus persicae. Further, Easthan and Mecully (1943) observed that both production and oviposition of eggs in Calendra granaria markedly decreased in the absence of moisture from the grain. According to Turnipseed and Rabb (1963) who observed that production of eggs as well as oviposition was ehhanced in the tobacco wire worm, Conoderus vespertinus by feeding on high concentration of protein and sugar as compared to those which received poor concentration of these substances in the diet. Similarly, Senge, et.al. (1971) found that the reduction in fecundity of Pseudant alaspis penlagona and Pludia interpunctella was 42% and 32% respectively wheh reared on pre-irradiated food.

From the above observations on the effect of different types of food it is evident that almost all species (particularly monophagous or oligophogous ones) thrived best on some one or few crops which contain substances best suited for its optimum growth and reproduction and other biological processes. Thus these findings can be helpful in manipulating some of the cultural methods to keep the pest population at the minimum. Crop rotation, mixed croping, early or delayed cropping and preparation of varieties with altered proportion of different nutrients etc. are some of the practices where **this** information is of significant importance.

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